INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

APRIL 1960

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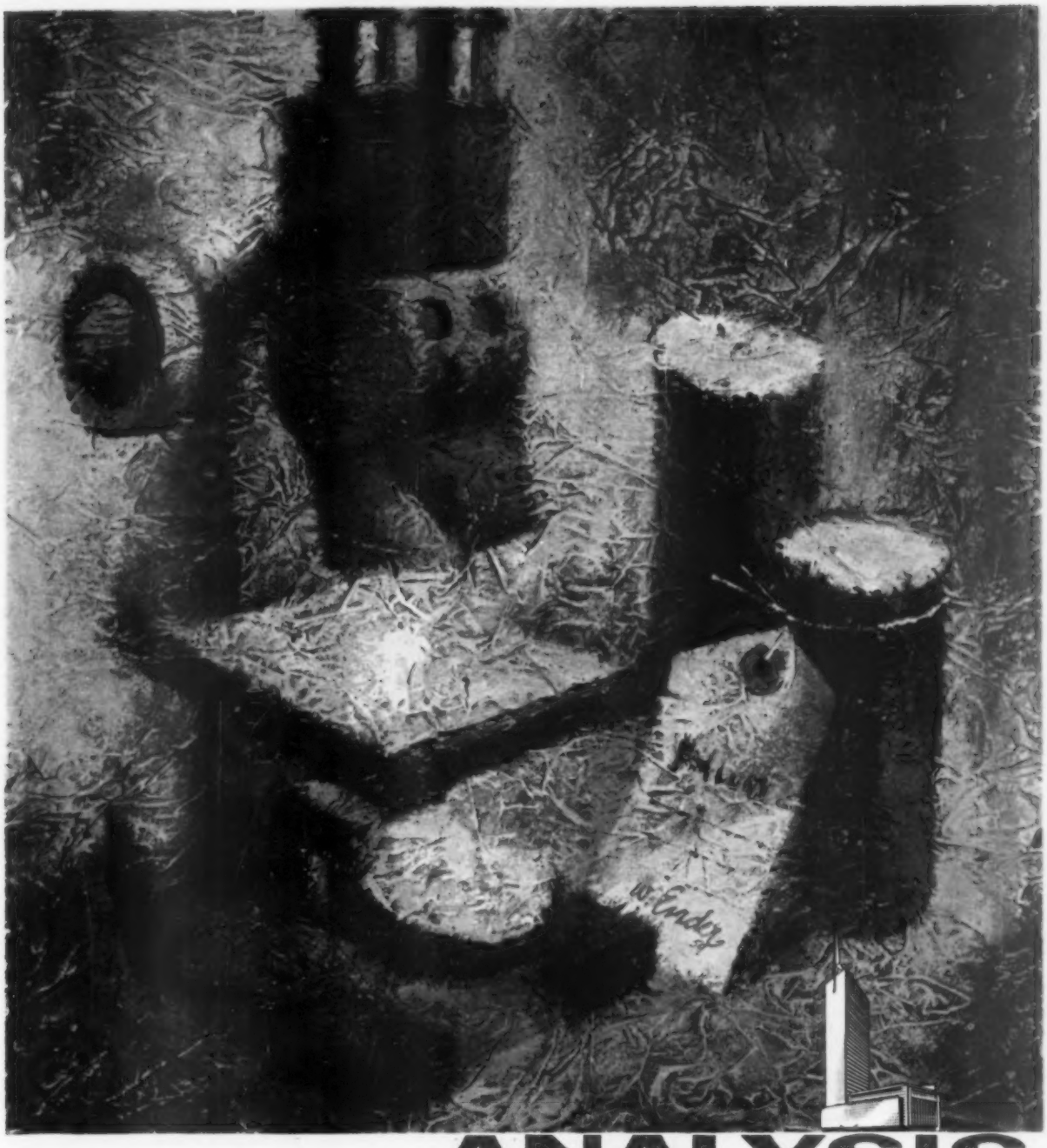

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THE PETROLEUM Engineer

FOR MANAGEMENT

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THE PETROLEUM Engineer
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COMING: A Renaissance in Petroleum

THERE'S A SPIRIT OF SEARCHING and researching in the petroleum industry today that presages a resurgent growth. In our first 100 years, we've had some breakthroughs — usually scientific or petroleum reserve discoveries that lifted the industry to higher levels.

One indication of the new avenues opened for progress is our past two years in the doldrums. Seeds of growth are planted in days of reverses. Long ago the Dark Ages was a time of gloom and despair, of clinging to dying customs, of solidifying limitations. Then man broke from his medieval culture — pulled loose his political chains — flung himself onto that galloping terror, the industrial revolution, and rode it into economic freedom.

The spirit of the Renaissance was nourished in the days of trial. The solid foundation for petroleum industry advances are built during the dim years of adjustment. Outmoded methods, endured in good times, are scraped away. Departments that have been piled with chores are cleared again for functional duties. Corporations get streamlined. Mergers provide better balance. Small new companies are established. Budding techniques are pulled from the laboratory into practical use. Suddenly a great industry is ready to climb the curve to a bigger, more complex, more rewarding level.

OUR INDUSTRY IS MOVING NOW. You can see the indicators clicking and the arrows pointing: ➔ Capital expenditures in 1960 will be the greatest ever invested by the world industry. ➔ The largest bonuses ever paid were bid last month for tidelands leases — a sure sign that oil companies know production is there and that they'll need it in the future. Highest amount on record was spent on deep wells in 1959 (yet wells cost less) and more money will be allocated this year. ➔ Refiners have shown superior judgment by cutting back runs in U. S. and this year they expect to use capital investment principally for modernizing and automating, the first time since World War II when we've got down to really fighting the battle of efficiency in our plants. Until recently, expansion has been more important. ➔ We've learned a lot about transportation and 1960 will see better economics and smoother operations in gathering, transporting and distributing oil and natural gas and their products.

Our dark years have been shadowed by stiffer government regulations, reverse judicial decisions, and heavier taxes. The Natural Gas Act interpretation by a not-so-temporal Supreme Court showered us with so much red tape you couldn't see the light. The independent gas producers are still in a tangle but the bonds aren't fixed and we hope to straighten the situation out.

That justice isn't wholly blind was shown in the dismissal of the case against 30 oil companies for price conspiracy. If you can't raise the price of crude oil, then you can't lower it either, so you are in a price cage of the Dark Ages. But the court reaffirmed our free enterprise principle that you have some say in the price of what you sell or buy.

We've had our germination in a couple of grim years. We're breaking into a greater future. It's the first year of the Renaissance in Petroleum — Our second century.

Ernestine Adams

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Petroleum Profile

RALPH GWIN FOLLIS
Chairman of the Board
Standard Oil Company of California

AT FIRST GLANCE you might not see Ralph Gwin Follis as an adventurer. Because he has been so successful his tilts with fortune take on solid conservative dimensions they have gradually earned.

He comes by this "nothing-ventured, nothing-gained" attitude naturally. Early ancestors came to America from Ireland in the 18th century and two great-grandfathers braved the trip across the continent to California in the gold rush of 1849. They found gold and settled in San Francisco. The family prospered and its men looked to mining engineering as careers. As a matter of course, when Ralph Gwin Follis was ready for college he entered University of California School of Mines. Although at that time gold mining was still a profitable business, young Follis was stirred by his dean's advice to get into something dynamic. Next year he went to Princeton and majored in geology.

In the summers, beginning when he was 17 years old, Follis worked in the oil fields near Taft, California. "I couldn't get a job with Standard of California," he recalls. "They had their choice of all vacation help."

By the time he graduated from Princeton in 1924 the tall, slender youth had worked up to a $225 a month driller's helper job. All the same, when Standard of California offered him $157.50 to begin as a geologist in the engineering department, he took it.

There were no management development programs at the time, but accidentally Follis got his own. He went from geology and engineering to refining, working on cracking research when the process was just emerging from the laboratories. One of the first plants to use it was the company's El Paso refinery and Follis was sent there for two years as superintendent.

Back in San Francisco he went up the ladder, making vice president of refining and research in 1942; president three years later, vice chairman in 1948, and chairman in 1950.

Demands of a company have great influence on its officials and when Mr. Follis became president in 1945, Standard of California needed reshaping. The company had grown from a dismembered part of the broken Standard Oil Trust in 1911, to a strapping, aggressive corporate entity competing internationally with giants of the world industry. It operates in 40 states and in more than 70 nations.

At this point it demanded an executive who could rebuild a straggling organization. All lines of subsidiaries and affiliates led straight to the top, like a country bank with the president deciding every loan.

Follis took to this venture into intangibles. He didn't hurry but he never stopped. He and other top management worked out a decentralized administration with close but not too restrictive ties to the home office. As chief executive, he was responsible for building the company's structure on innovated — and some original — designs. To assess the results briefly — it works, and its stress on giving individuals opportunity contributes to the high morale and spirit of progress apparent in Standard of California companies.

Part of this is due to an orderly and continuous study and analysis of management and management development. The program was formally established in 1946 about a year after Mr. Follis became president. Under his direction *The Management Guide* has been developed which defines the functions, responsibilities, authorities, and principal relationships of management positions at all levels. It has attracted wide attention in U. S. business and industry. The Guide has been helpful in the tremendous task of modernizing the company organization. Its limitation is best illustrated by the fact that it describes Mr. Follis' job, which is just about impossible to wrap up in words.

There aren't many persons who do more traveling than Chairman Follis. His is not a desk job. He crosses the North Atlantic Continent about once a month, takes turns covering operations in the Eastern and then Western Hemisphere, one each year. His company has interests in some 75 nations in the world. He is deputy chairman of American Gilsonite Company.

Asked about the present oil situation, Mr. Follis said, "We're getting back to normal. We've had 10 years of abnormally rapid growth. Until we replaced the oil used in the war, we had to move fast. Slower growth isn't all bad. If our gains had continued at such an abnormal rate, political pressures would be heavier. This takes most of the ammunition away from our attackers."

He is also pleased about oil prospects in North Africa. Although his company has huge investments in the Middle East, he feels competition of supplies in other countries benefits the industry.

Mr. Follis is married and has two children — a daughter who is married, and a son, Jim, who is studying law at Harvard after getting his B.A. at Princeton.

The Board Chairman of Standard of California is a trustee of Princeton University, of American University of Beirut, and of Stanford Research Institute.

And what about recreation? "I like to hunt and fish when I have time, but I don't think anybody in the oil industry needs a hobby," Mr. Follis said with one of his sudden friendly smiles. He went on, "Everything needs oil products. You become interested in many businesses and industries through their use of petroleum. There's simply no time for boredom."

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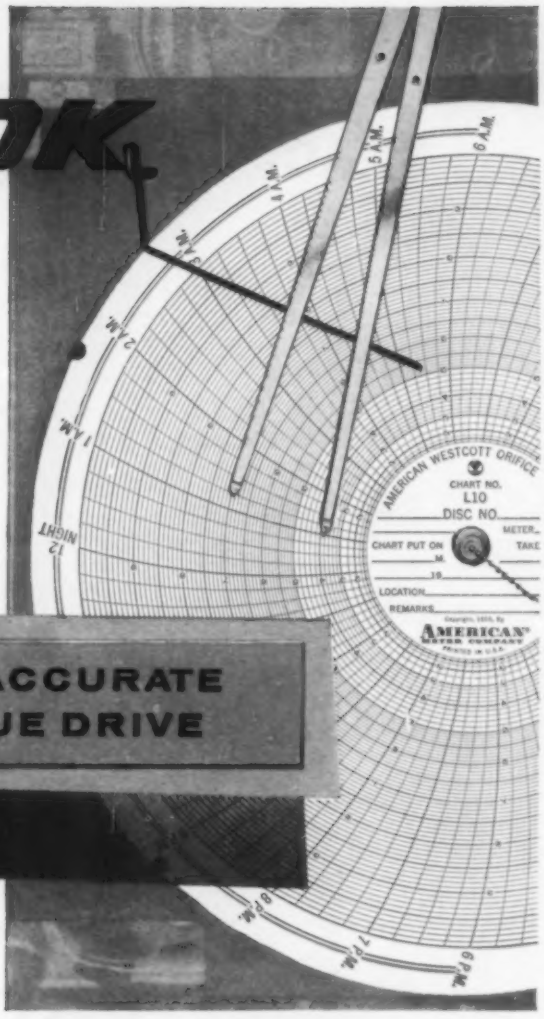

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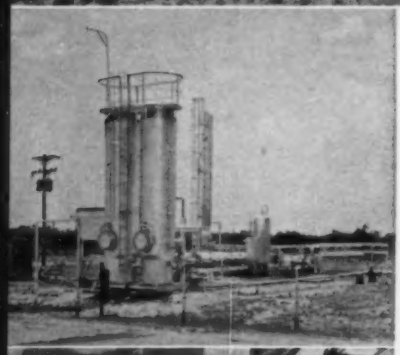

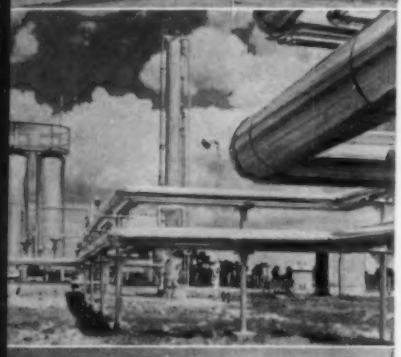

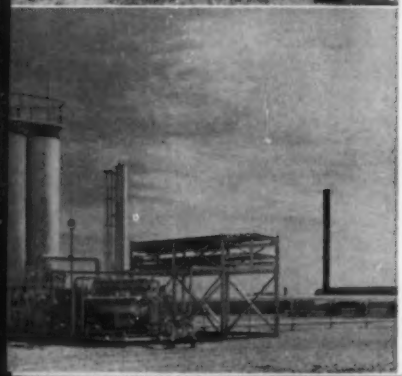

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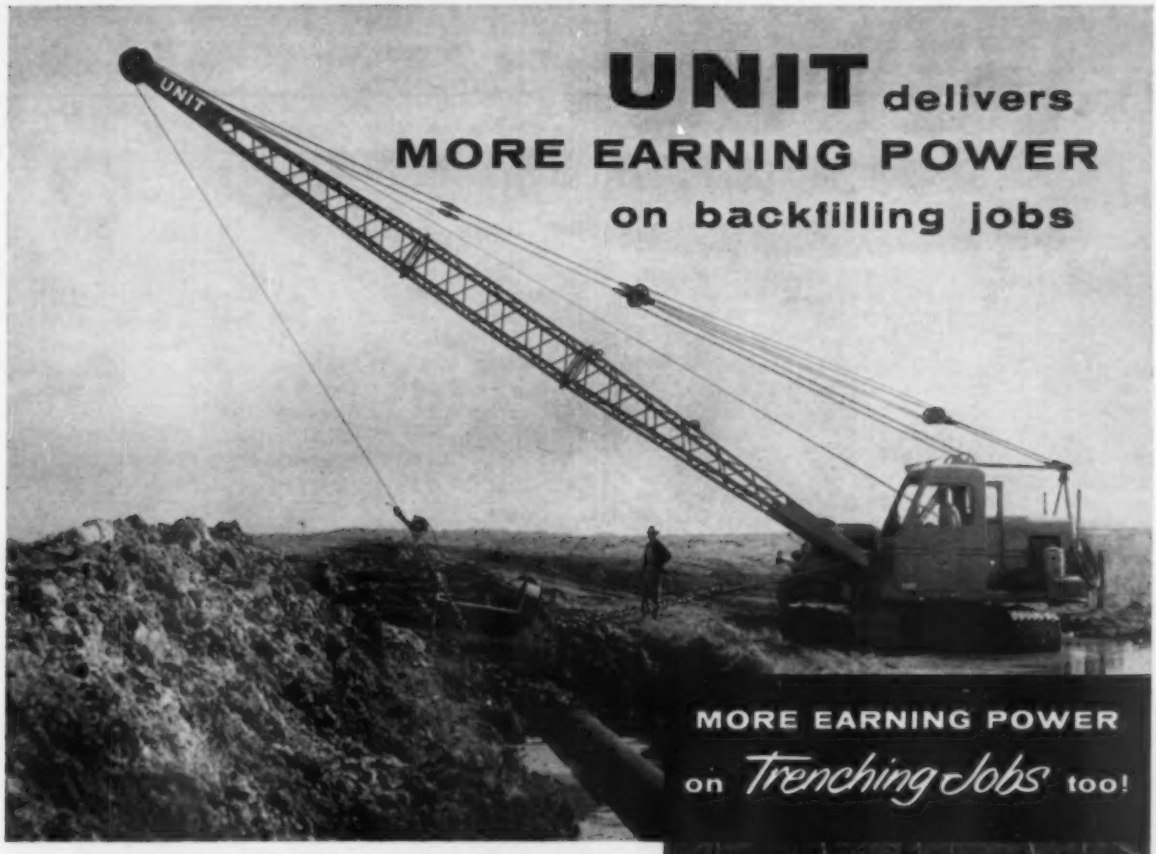

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Highlights and footnotes

FREEDOM AWARD FOR API . . . STATES TO GET CUT-RATE PRICES . . . IMPORTS TO USA GIVEN . . . ENI PLANS RECORD EXPANSION

State Gets Bargain. New York state has made a contract with American Oil Company which gives state employees driving on official business the right to purchase gasoline at 1½ cents a gallon discount. Other oil companies may make similar contracts. The state of Oklahoma recently completed arrangements to buy gasoline and oil from service stations at less than regular costs. The camel's nose is under the tent.

Freedom Awards. The American Petroleum Institute and its Secretary, Willard M. Wilson, have received awards from the Freedoms Foundation. The API was named for its publications last year covering the oil industry's 100th anniversary. Wilson was cited for his address to the Holdredge, Nebraska high school graduating class.

Gas Price Cut. FPC granted permament certificates to 17 producers in the Aneth field (Four Corners) after cutting proposed initial price of 20 cents per Mcf to 17.7 cents. November 19 the FPC gave temporary authority for the producers to sell to El Paso Natural Gas for 20 cents until rate was determined. Under *temporary contracts service "may not be discontinued without permission."* This business is more permanent and more floating than any crap game.

Librarians Deliberate. Some 200 oil industry librarians met in Dallas in February to decide how to provide their industry with easier access to the mass of technical literature. One fact all agreed to, information is costly in intellectual effort and in the expense of reproducing it.

ENI to Expand. Plans released by Italian Minister for State Holdings include 103 billion lire ($165 million) for ENI, state-owned firm, to invest in research, transport and distribution of methane, and other petroleum products, petrochemical industry, etc. Considering the extent of ENI's domain this is not large but is good for a government entity. Phillips, Sinclair and Cities Service will each spend more.

Cuba in Oil Biz. The National Petroleum Institute, a subsidiary organization of National Agrarian Reform Institute (INRA), the all-powerful Cuban government agency, is set up to go into refining and marketing and eventually into drilling and exploration. Already it operates one small refinery and plans to build another. At present Cuban refineries are owned by Texaco, Jersey Standard and Shell. Labor problems and profitable government interventions are constant hazards. Castro needs the lasting powers of Batista to carry out his plans.

Brass Collar. National Labor Relations Board reports 209 polls on Union organizations were held in 1959 for white collar workers as compared with 165 in 1958. Unions won less than half the elections and won bargaining rights for about one-third of 10,250 participants. This may be less than in the last two years but accumulative effect is what counts. As the easy ones have got into the unions they have more time to work on the hard-to-get ones.

IMPORTS OF CRUDE OIL, UNFINISHED OILS, FINISHED PRODUCTS AND RESIDUAL FUEL BY COUNTRY OF ORIGIN

(Period March 11, 1959 through December 31, 1959)[1]

(Figures in M B/D)

	Bahrein	Borneo	Brazil	Canada[2]	Colombia	Cuba	Iran	Iraq	Italy	Japan	Kuwait	Mexico	Netherlands Antilles	Neutral Zone	Qatar	Saudi Arabia	Sumatra	Syria	Trinidad	United Kingdom	Venezuela	TOTAL
District I-IV																						
Crude Oil			3.5	56.0	32.5		3.5	18.3			118.8			20.2		43.2		3.7	—	—	417.2	716.9
Unfinished Oil			0.3						0.5		10.2		0.5					—	3.1	—	12.8	27.4
Finished Product											0.5		42.0					—	0.8	.7	28.6	72.6
Residual Fuel	0.3		0.4	.9	0.4	0.7					12.1	24.2	107.8	4.3		0.3		—	1.4	.8	201.0	354.6
Sub Total	0.3	—	4.2	56.9	32.9	0.7	3.5	18.3	0.5	—	141.6	24.2	150.3	24.5	—	43.5	—	3.7	5.3	1.5	659.6	1171.5
District V[3]																						
Crude Oil		13.6	—	38.4	2.6	—	25.0	—	—	—	31.0	—	—	20.2	0.03	17.5	52.6	—	0.5	—	39.9	241.3
Unfinished Oil		0.05	—	0.2	—	—	—	—	—	3.0	1.6	—	0.6	0.2	—	—	—	—	1.7	—	5.4	12.7
Finished Product	—	—	—	0.9	—	—	—	—	—	—	—	—	4.9	—	—	—	—	—	—	0.001	0.7	6.5
Sub Total	—	13.6	—	39.5	2.6	—	25.0	—	—	3.0	32.6	—	5.5	20.4	0.03	17.5	52.6	—	2.2	0.001	46.0	260.5
Puerto Rico																						
Crude Oil	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	65.5	65.5
Unfinished Oil	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11.3	11.3
Finished Products	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.9	1.9
Residual Fuel	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.5	1.5
Sub Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	80.2	80.2
Grand Total Imports	0.3	13.6	4.2	96.4	35.5	0.7	28.5	18.3	0.5	3.0	174.2	24.2	155.8	44.9	0.03	61.0	52.6	3.7	7.5	1.5	785.8	1512.2
Percentages of Total	.02	0.9	0.3	6.4	2.3	0.05	1.9	1.2	0.03	0.2	11.5	1.6	10.3	3.0	—	4.0	3.5	0.2	0.5	0.1	52.0	100.00

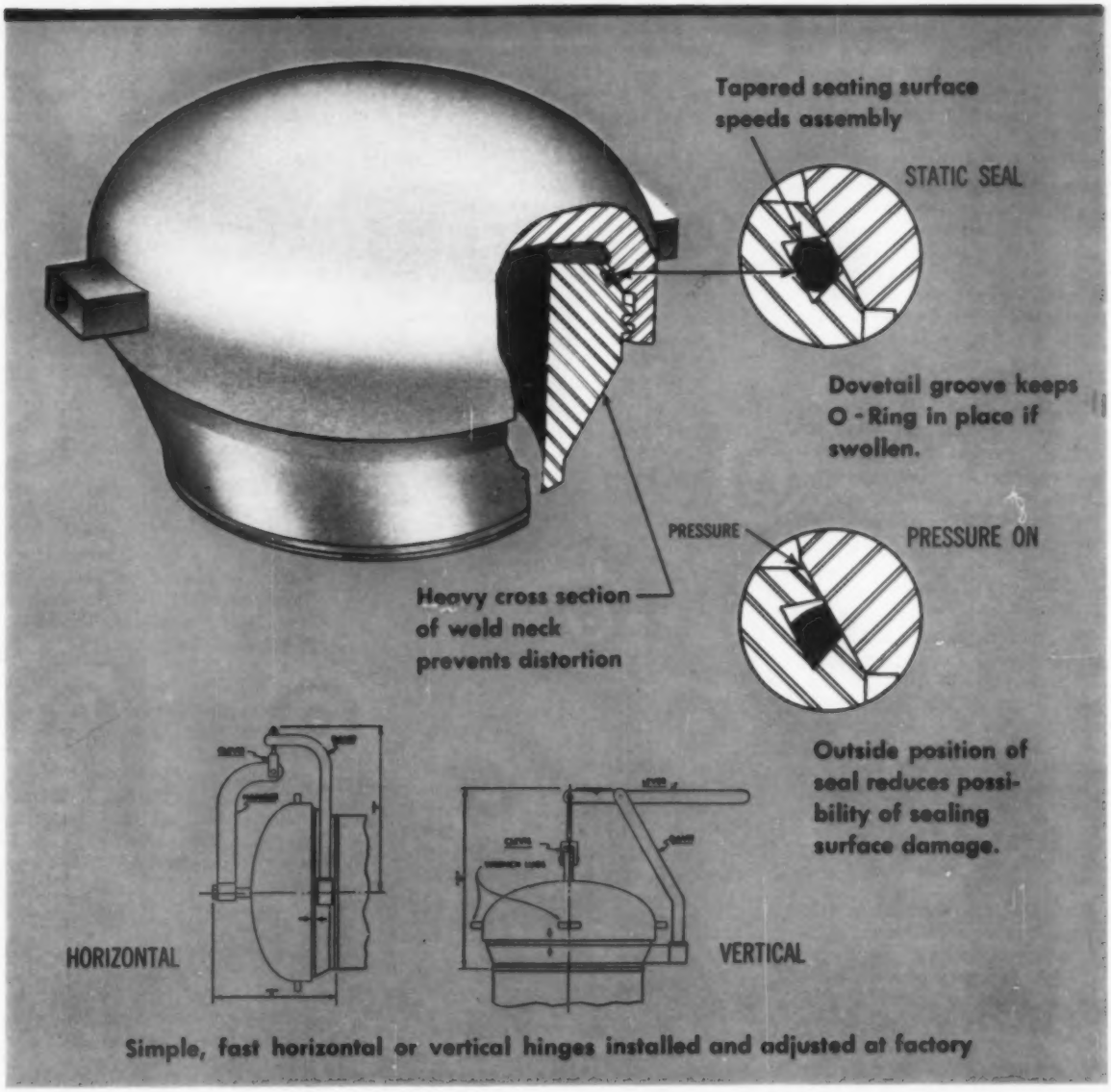
Note [1]Period for Finished Products and Residual Fuel — April 1, 1959 through December 31, 1959.

[2]Since June 1, 1959 all imports by overland means are exempted (Proclamation 3290).

[3]Alaska, Arizona, California, Nevada, Oregon and Washington.

Peerless Development in O-Ring Closures

Results in: (1) Lower Cost (2) Better Operation


Tapered seating surface speeds assembly
STATIC SEAL
Dovetail groove keeps O-Ring in place if swollen.
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Heavy cross section of weld neck prevents distortion
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Highlights and footnotes

Oil Flow Cut. Texas Railroad Commission cut oil allowable to 9 days for April from 10 days in March. Most witnesses ask for 8 days. New Mexico Conservation Commission set a 35 b/d quota, a drop from 36 b/d in March, 37 b/d in February.

Idaho Applies. Interstate Oil Compact Commission received an application for associate membership from Idaho. This will make a total of 30 member states and 3 associate member states. Action on the application will be taken at the mid-year meeting at Detroit, June 13-15.

Pure Buys Woodward. For 1,193,881 shares of common stock, Pure Oil Company has obtained all assets of Woodley Petroleum Company, Houston, Texas, a producer and marketer. In 1959 Woodley averaged 9,477 b/d in U. S. and Canada.

Strike in Alaska. Standard of California and Richfield hit again on the Kenai Peninsula with a well that on the first test made 1870 b/d. It is 2 miles south of the first discovery and tenth test to evaluate area. Out of the 10, seven producers were drilled. This is beginning to look like another bonanza. Supply gallops while demand pokes. Is this a hare and tortoise race?

World Output Up. Bureau of Mines estimates Free World crude oil production was up 11% the first half of 1959. Refined products increased 7%, showing the rising economic activity last year. World domestic demand for refined products was 8% above first half of 1958—7% in United States and 9% in rest of Free World.

Fifteen Company. Tennessee Gas Transmission has moved to acquire Fifteen Oil Company on a stock purchase basis.

Refund Rate Up. Federal Power Commission raised to 7% from 6% the interest natural gas producers and pipeline companies must pay their customers on rate refunds. When considering proposals to boost gas rates, FPC may suspend decision for up to five months. If the case is not settled by then, the company may put the higher rates into effect subject to refund—plus interest if FPC ultimately finds the increase unjustified.

Chemical Sales Rise. In Europe, between 1953 and 1958, the chemical industry's sales for the European Common Market rose from $6.4 billion to $10 billion. This is reported by the Organization for European Economic Cooperation. As economic integration moves ahead with the Common Market, more opportunities should arise, also more competition for the USA.

High Bonuses. Oil companies bid a record $285,180,648 for leases offshore from Texas and Louisiana. One track off Louisiana brought $11,112,000 from Gulf and Socony. Shell paid the highest Texas lease—$5,911,200. Evidently oil companies figure they're going to be in business a long time, cause it's going to take a few years to make this investment pay.

$300 Million. That's the amount held in escrow that has come from sales of offshore leases claimed by Gulf states and Federal government. The area in dispute is from 3½ to 10½ miles out to sea. Lease bonuses are set aside until Supreme Court decides which is owner. Congress, which was supposed to settle this in Tidelands bill, is getting crossed up again.

Compensation Set. Report is that the Austrian government will pay $13,700,000 to companies that lost their oil concessions due to the war. The money will go to Socony and Royal Dutch/Shell. The idea of granting the companies participation in further operations seems to be lost in the shuffle—may turn up later.

Canadian After Husky. Canadian Husky Oil, Ltd., is trying again to acquire Husky Oil of Cody, Wyoming. New offer is eight common shares of Canadian firm for each nine of U. S. company.

It's Spring—Tra La! Richfield dealers have been supplied with fresh 1960 wild flower seeds to be given to service station customers. Also the company supplied a catalog of "Western Wild Flowers" with 50 color photographs. A promotion not as common as trading stamps, we'd say.

Litton Expands. Western Geophysical Company of America has become an operating subsidiary of Litton Industries, an electronic firm. Henry Salvatori will remain as chairman and chief executive, Dean Walling as president.

Refinery Runs Cut. Reductions in refinery runs came one after the other in February and March. Standard Oil (Ind.) cut runs by 142,000 b/d, Esso Standard by 50,000 b/d, Atlantic by 23,000 b/d, Phillips by 17,000 b/d, DX-Sunray by 5000 b/d, Conoco by 14,000 b/d, Tidewater by 25,000 b/d, etc. Refiners were trying to get some kind of inventory balance.

Delhi-Taylor/Billups Deal. President of Billups Eastern Petroleum, H. H. Peyton, and J. L. Sewell, president of Delhi-Taylor, announced that Delhi-Taylor has purchased substantial common stock interest in Billups Eastern, an independent marketer on the Eastern seaboard.

Venezuela Hurting. Since the 1958 tax rise the Venezuelan oil industry has been deflated. After a year under the new tax, some results are obvious. Profits dived and took government returns with them. Capital outlays were a third less than 1958. Not half as many wells were drilled in 1959 as the year before. Although world conditions have contributed, this has been a minor factor.

Buy Properties. General American (and others) purchased for $73,500,000 some South Louisiana producing properties from Joe W. Brown estate and from John W. Mecom. President Gordon Simpson said acquisitions closed or in process of closing, will add 21 million bbl of crude and 275 billion cu ft of gas to General American reserves.

Good Wells Make Good News

A Report on Recent Engineered Acid Treatments

April, 1960

Dowell engineers can now use more proved services, products and techniques than ever before to design effective acid treatments. Here are four recent treatments that used advanced engineering to good effect.

- **Spencer County, Indiana** (New Oil Well) This well made a show of oil upon completion into the Rosiclare. The pay is a dirty lime. Dowell recommended acidizing with 3000 gallons inhibited acid. Two Dowell addition agents were used to prevent emulsions and control silicate swelling. Injection rate was held to 1.5 bpm during treatment. 30 days after treatment well tested 95 bopd with no water — an unusually good well for the area.

- **Central Alberta, Canada** (New Oil Well) This well was completed in the Slave Point formation on the edge of a pool in the Swan Hills region. The pay is a fast-reacting limestone. There was no production and the operator considered abandonment. Dowell engineered a treatment using the "Acid Guide"*. The formation was washed 4 hours with 500 gallons Mud Acid. Then 500 gallons Retarded Acid was squeezed into the formation at one bpm and 3800 psi. After treatment, the well made field allowable and was put on production.

- **Eastland County, North Texas** (New Oil Well) This well went to water after conventional perforating and acidizing. The operator squeezed with Cealment*, latex-cementing service; then used Abrasijet*, abrasive-fluid jetting service, to re-perforate into the Marble Falls conglomerate from 2955 to 2968 feet. Next, 250 gallons Dowell acid were jetted into the formation through the tool used in Abrasijet. Before treatment, well produced 100 per cent water. After treatment, it produced 25 bopd with no water.

- **Lea County, New Mexico** (Old Oil Well) This well had depleted the McKee sand and was plugged back and re-completed in the Abo limestone from 7122 to 7226 feet. Core analysis showed iron compounds to be present. Dowell recommended Stabilized Acid to prevent the possible precipitation of gummy iron hydroxides. 6000 gallons Stabilized Acid were injected. Perforation ball sealers were used during treatment. Production increased from a show to 200 bopd (with no water) through a 20/64th-inch choke.

Engineered acidizing by Dowell helps you improve profits by getting maximum return from your acidizing dollar. For service or detailed information, contact the Dowell office or station nearest you. Dowell services and products are offered from more than 150 locations in the United States, Canada, Venezuela, and Argentina. Dowell, Tulsa 1, Oklahoma.

*DOWELL TRADEMARK

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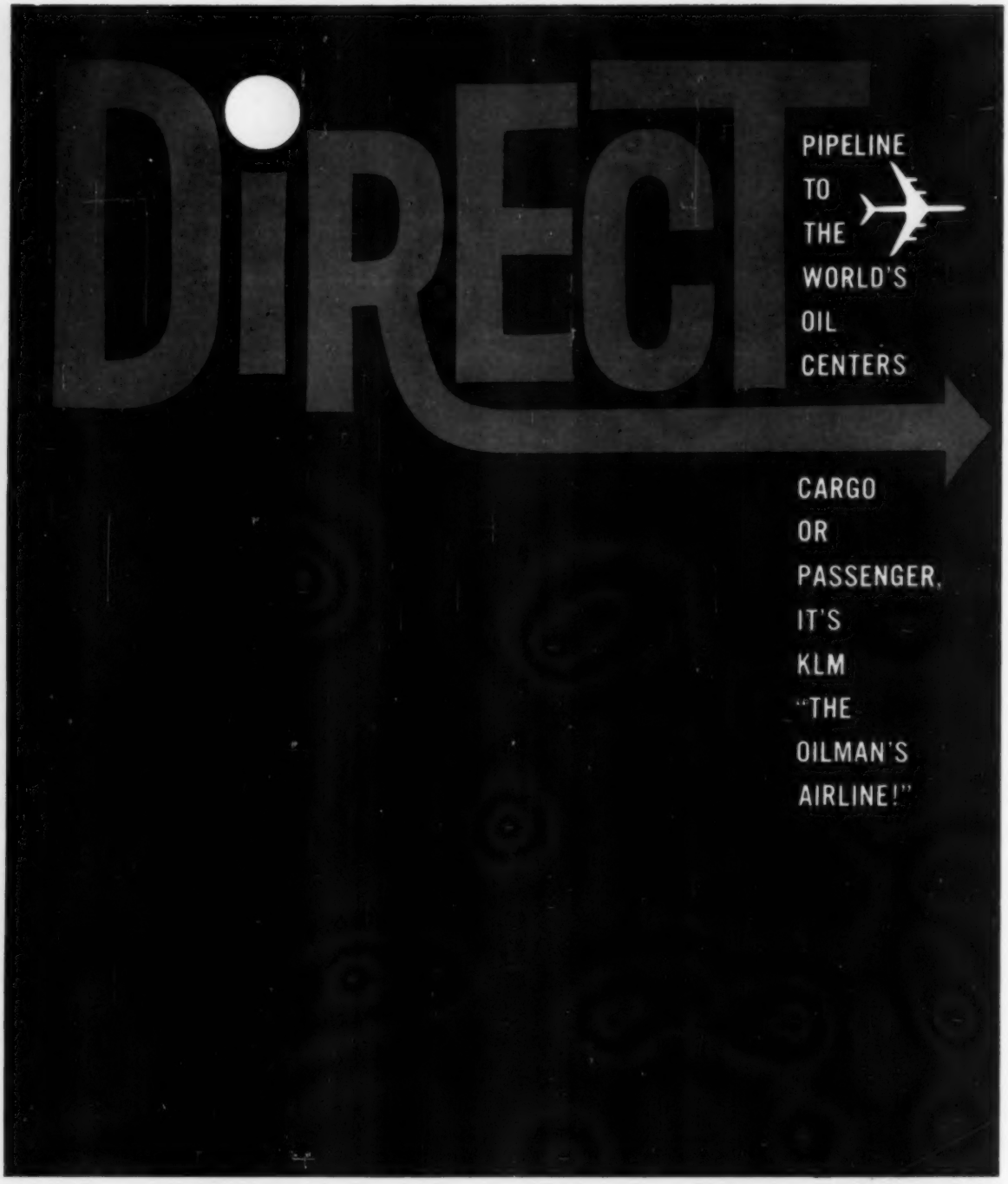

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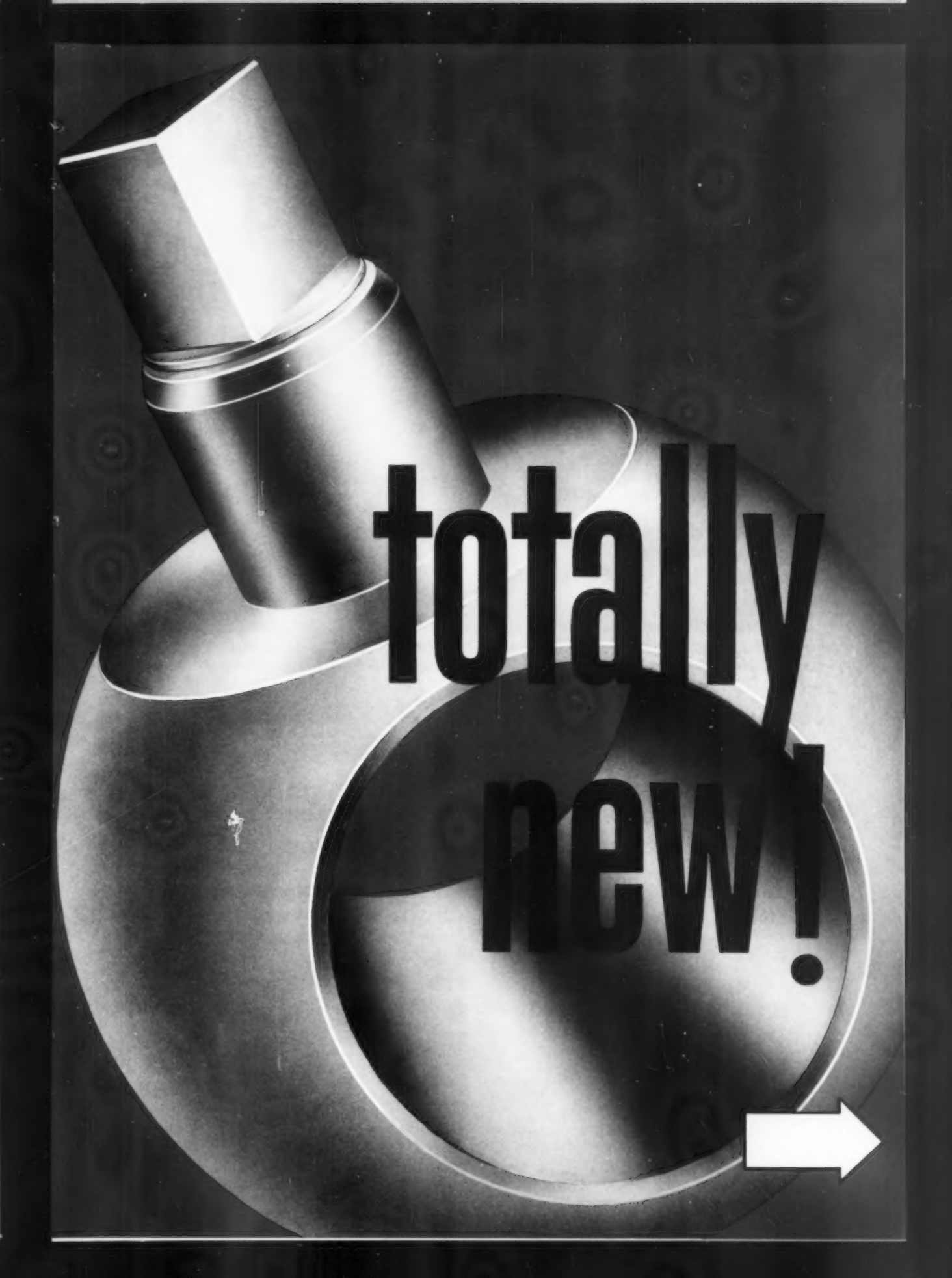
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new!

Only *FLO·BALL* valves are bearing-fixed for maintenance-free long life!

. . . with all the features you must have:

- **Top loading**
- **Replaceable seats**
- **One-piece ball and stem**
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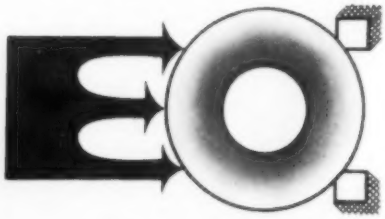
Series 711, 150 lb. ASA Flanged, Reduced Port

Now available . . . the result of years of intensive service in the missile-space industry . . . proven in thousands of adverse applications . . . now at mass produced prices . . . the most advanced line of ball valves ever manufactured . . . for you!

ORDINARY BALL VALVE

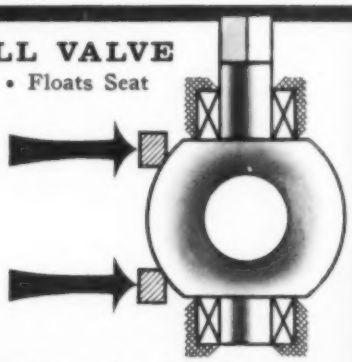
Floats Ball • Fixes Seat



Floating ball puts excessive pressure load on fixed seats. Results in distortion and short life.

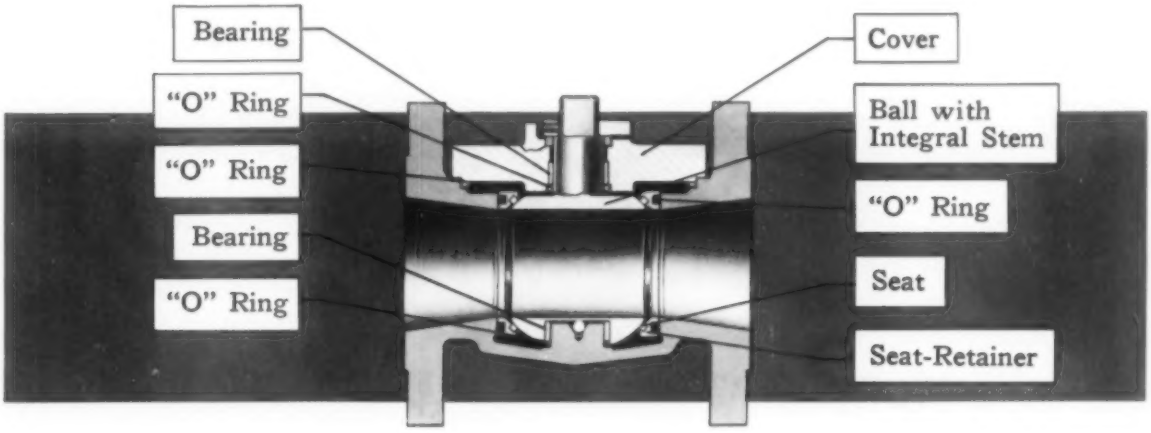
FLO • BALL VALVE

Fixes Ball • Floats Seat



FLO·BALL bearings absorb all pressure forces. Elimination of excessive seat loading insures long life.

The Series 711 ***FLO·BALL*** valves are available for off-the-shelf delivery. Manufactured to standard ASA dimensions in carbon steel, 316 stainless steel, and aluminum for body and ball, Teflon for seats, and Buna "N" O-Ring seals. Other materials are also available. These valves operate at pressures to 300 psi, temperatures to 400° F.



The Hydromatics Series 711 FLO•BALL valve gives you the features you must have!

- Bearing-Fixed ball. Engineered to withstand shock and impact without distortion or backlash.
- Top loading. Valve can be disassembled and assembled without removing it from line. No special tools are required.
- Self adjusting, replaceable seats. Both balanced seats are self-aligning and self-adjusting for controlled seat loading and positive seal.
- No lubrication. Operates completely without lubrication.
- Zero leakage. At all operating pressures, including vacuum to 10^{-6} mm. of Hg.
- One-piece stem and ball. Simplified construction adds strength, precision and lower torque.
- Maximum flow efficiency. The open ***FLO·BALL*** valve provides an unrestricted, straight-thru fluid path.
- Lowest torque. Bearing-Fixed construction results in effortless, fast-action with low torque.
- Two-way flow. Exclusive ***FLO·BALL*** seat design principle insures perfect seal in both directions.

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FLO-BALL

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Gentlemen:
Your Bearing Fixed Flo-Ball valves from ⅛" to 24" may help solve a problem relating to the control of:

☐ Corrosive Liquids ☐ Cryogenic Liquids ☐ Throttling Flow
☐ Vacuum ☐ High Pressure

My flow problem is_____

I now use Ball Valves in these sizes_____

PLEASE: ☐ Have salesman call ☐ Send technical data

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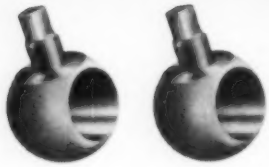
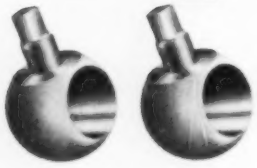


New Zero leakage

Maximum flow

Top loading

New



No lubrication

One piece ball and

stem

New

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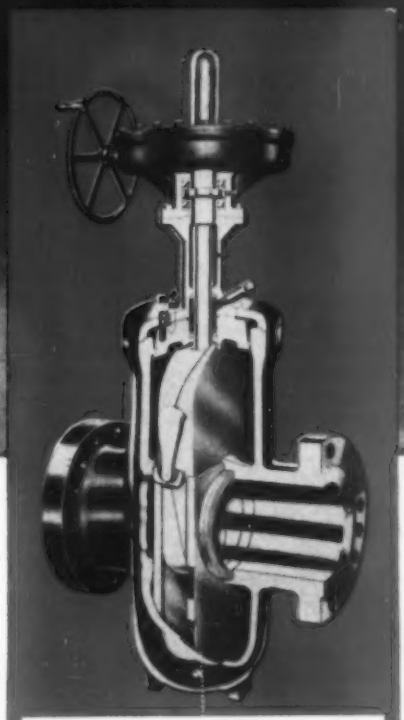

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More than 300 rigid inspections certify the precision quality and long life that's built into every W-K-M pipeline valve. That's one reason W-K-M valves are recognized the world over for their superior construction and outstanding performance.

No other valves give you the same long-lasting service and economy. No other valves require so little maintenance.

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THE CONFERENCE TABLE

"The best ideas are common property." — SENECA

Oh! That Russian Competition

In a speech in New York, Kerryn King, chairman of API's Committee on Public Affairs, said the United States must double its supplies of petroleum by 1975 if it hopes to raise living standards and compete successfully with Communism.

He points out that Russia has already given top priority to oil and gas production in its plans for the next seven years. Mr. King, who is a vice president of Texaco, Inc., said that U. S. petroleum exploration and development must be maintained in a healthy and dynamic condition in order to hold our own in the cold war.

On page E-2, this issue, is a story of the all-out effort by the Soviet on gas development. We, too, believe that this country appears to be falling into the same trap that Stalin did — saving oil and gas reserves and developing coal reserves even though coal is a higher price energy and less efficient.

In some ways this comparison between Russia and the United States is becoming a cliché but our purpose here is to point out to those who would control energy through the Federal government that Russia's little experiment of holding back oil and gas in favor of coal did not exactly turn into a big success. National planning is never as safe as weighing values in the market place.

Ideas on the Market

The Densometer was developed by Halliburton engineers to weigh cement slurry pumped into an oil well during cementing. Because of employee suggestions the instrument is being studied for weighing fluids in chemical plants, missile development, food processing and other industries where fluids must be weighed precisely.

This is one result of special attention to employee recommendations. President L. B. Meaders says that Halliburton has learned not to down-grade ideas just because they originate among non-technical personnel and the company has learned, too, to investigate every idea regardless of how unlikely it might appear.

✔ *An economy runs best when least encumbered by economic theory.*

Economic Policy Spelled Out

The Research and Policy Committee of the Committee for Economic Development reports that the "size and character" of United States deficits in its balance of payments with other countries *demand policy changes here and abroad* to reduce the outflow of gold and dollars, which amounted to $3½ to $4 billion a year in the last two years.

The Committee said, in a statement on national policy, that "We can and must correct our balance of payments position in ways that are consistent with the major objectives of national policy."

Among the recommendations for policy action in today's statement were these:

1. Increase the "attractiveness of American goods and services in world markets." The main instrument suggested for doing this "will be found in the domestic economic policies of the government and in the actions of business and labor. A strong anti-inflationary fiscal, monetary and debt-management policy at home is the first requirement."

2. Reduce or eliminate restrictions, imposed by other industrial countries, that limit purchases of United States goods, travel in the United States, and investment in the United States.

3. "The scale of the contribution of the United States to the costs of the common defense and of economic assistance to the underdeveloped world should not be determined by our balance of payments position." Nevertheless "the rise in the national incomes of other industrial nations makes it appropriate for them to undertake a large contribution to the common burdens of defense and economic assistance."

✔ *What ends are we serving when capital, management and technology are strained to improve the quality of products while holding down their costs, only to have the successes of such a program dissipated by unreasonable demands by labor, constantly increasing and disproportionate motor fuel taxes and various forms of governmental interference?*

— Senior Vice President Naylor, Gulf Oil Corporation.

Look Who's Developing Management

A management development program was presented to the governing body of the International Labor Organization in Geneva recently. According to the ILO News, "The broad aim of the management development program is to assist industrialists and managers, including directors and managers of public undertakings in the less developed countries, to develop further the insight and managerial skills which will permit them to make the best possible use of resources at their disposal for the benefit of their undertakings, the people employed in them, and the community as a whole." (We'll take a moment to deplore that long sentence.)

It seemed a little strange to us that ILO should be one to meet the great demand for executive development in other countries, and at the same time, we wondered to what extent management itself has done anything to help foster executive talent in backward areas.

"Holier than thou is an attitude
That does not get us far.
It is met with thankless ingratitude
Despite the fact that we are."

Good Public Relations Story

Kenneth L. Dixon apparently hit the nail square on the head in his public relations story in the February 1960 issue. Here are some comments on it:

Bob Craft, Fort Worth, Texas, said: *"Just a note to express my appreciation for the very fine article that you had about public relations in your February 1960 issue — written by Kenneth L. Dixon. It was certainly down to earth and pointed up some of the problems that PR men encounter in trying to be understood."*

Maury M. Travis, Denver, Colorado, said: *"I want to congratulate Mr. Dixon on the very able, frank and valuable address reprinted in* Petroleum Engineer, *February 1960 (Public Relations Isn't a Luxury). Few oil companies have understood grass-roots public relations, and only recently have they understood the necessity to enter the field of politics. Please continue to talk and write further on this vital subject."*

L. P. Humann, Independence, Kansas, said: *"May I compliment you on the article 'Public Relations Isn't a Luxury' by Mr. Kenneth L. Dixon. It was a powerful and timely admonition to the industry to 'sharpen up'."*

Competition Abroad

A major manufacturing company reports that in 1953 a certain pump cost $244.96 to make it in its American plant and $148.96 in its foreign plant. In 1958, it cost $348.55 to make the same pump in the American plant, due to inflation and wage increases — while the cost to make it in the foreign plant had actually declined, to $140.57.

One Way to Put Up

Two handbooks and some special booklets on the "Greatest Election Campaign in History" are on the market now. The "1960 National Convention and Election Handbook" and the "Presidential Election Handbook" were compiled by United Press International. Contents are similar. Each shows how conventions are run and about coverage, TV tally sheets, delegates, platforms, etc.

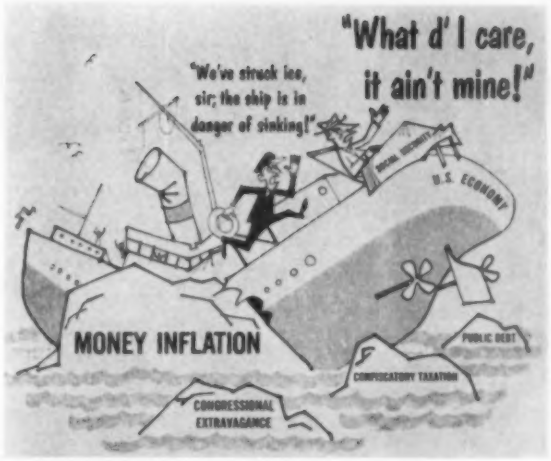
Small effective cartoon-type booklets offered include such attention-compellers as "The Price You Pay for Graft" plus "The Man Who Stole Your Vote."

These are available in quantity lots and although they are offered for advertising imprint, they would be excellent employee handbooks. Write National Research Bureau, 415 N. Dearborn Street, Chicago 10, Illinois for samples and prices.

Labor has become more expensive than capital thus providing an incentive for substituting capital for labor.

Letter to Management

Prentice-Hall (Englewood Cliffs, New Jersey) is publishing a bi-monthly Management Letter that will be of interest to some petroleum company staffs. Its emphasis is on markets — "To . . . Spur Sales . . . Trim Costs . . . Boost Profits" — but other oil departments could glean ideas. You are given a suggestion, have an example described, and are told what references would help. Such subjects as "Cut Production Cost," "Leasing: A Source of Expansion Funds," "A Checklist of Idea Sources for New Products and Services" are examples.


"What d' I care, it ain't mine!"
"We've struck ice, sir; the ship is in danger of sinking!"
U.S. ECONOMY
MONEY INFLATION
PUBLIC DEBT
COMPULSATORY TAXATION
CONGRESSIONAL EXTRAVAGANCE

THE CARTOON ABOVE was suggested to Union Oil of California by a man who read the company's ad on "What is the No. 1 Threat to U. S. Growth?" The reader said "The underlying force behind this threat is the indifference of the large percentage of our people to government interference in the affairs of private business. Exorbitant taxes, from the Federal government on down, are destroying the incentive of business to expand. The person who says 'What should I care if the government takes all the profit of Union Oil, Standard Oil, U. S. Steel, General Motors, etc.?' put himself in the same class as the man on the ship in Mid-Atlantic who, when the captain said the ship was sinking, said 'What do I care, it ain't mine!' "

Human Factors Studied

The most unpredictable and most enduring part in man-machine environment is the human factor which now has a magazine devoted to its study.

Human Factors is a new scientific journal published quarterly by Pergamon Press, Inc. on behalf of the Human Factors Society. New methods of study are being devised to keep pace with the explosive development of man's ability to manipulate nature. In this study, in which cross-fertilization between life sciences and engineering is encouraged, Human Factors are considered in relation to the machines and environments in which man works and plays.

The Human Factors Society is supported by Bendix, General Dynamics, General Motors, etc. — no oil companies. It is basically concerned with man in his use of machines.

Non-Work Becoming Big Business

In the United States more and more of us are being supported by fewer and fewer breadwinners. That is, in proportion. Of course, employment has risen but not as fast as the population so the number of non-workers has grown too. These, according to *Fortune* magazine, have roughly doubled in the past 10 years and may do so again by 1970. Today they come to around 5,500,000 people who do not work, and this excludes people over 14 who are going to school, keeping house, or looking for work.

So, we have about 15 percent of all the personal income in the nation paid out for non-work. That is, for social security payments, life insurance, private pensions, dividends, interest and rent, and various payments from federal, state, and local programs. Not working has become big business. No more is the leisure class the aristocracy — it's the man collecting unemployment insurance or his pension.

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- SWEEP ARM AGITATOR HYDRAULICALLY DRIVEN — Scrapes all coke deposits from kettle bottom . . . assures complete agitation in lower area of kettle.
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- LARGE CAPACITY—To reduce number of kettles needed for "big inch" jobs. Saves time in changing out kettles in operation.
- EXTRA LARGE LOADING DOOR — For high speed kettle charging.
- INSULATION — Heavy duty asbestos concrete for bottom and sides of kettle tank.
- UNITIZED CONSTRUCTION — Heavy 10" structural steel channels for primary members with support members welded to them for maximum strength.
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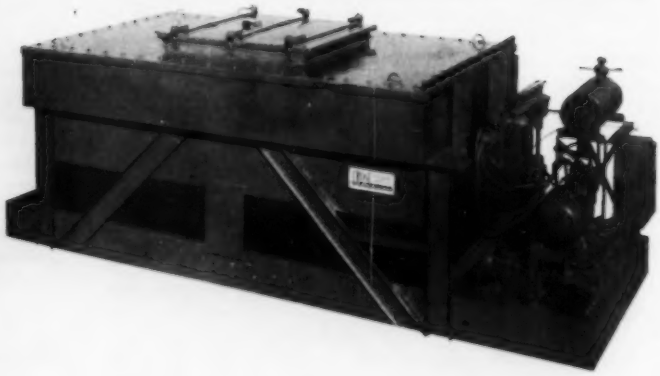
- POWER UNIT — Self-starting air cooled engine. Electric or air cooled diesel power units available as optional equipment.

NEW KETTLE FOR STATIONARY YARD WORK

This new skid-mounted Crose-Littleford kettle has complete electric drive. Its burner — for either natural gas or propane — has pilot light and main burner with high-low flame arrangement for thermostatically controlled temperatures. Electric hot spark ignites burner flame, with provision for automatic cut-off in event of flame blowout or fuel supply failure. Temperature recorder available as optional equipment.



CROSE-LITTLEFORD PIPELINE KETTLES ARE AVAILABLE IN THREE SIZES: 10-BARREL, 23-BARREL, OR 30-BARREL CAPACITY. ALSO, 75-GAL., 165-GAL., 225-GAL., AND 325-GAL. PATCH KETTLES AVAILABLE

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Installed on caustic lines in 1930, these Rockwell-Nordstrom lubricated plug valves needed only cleaning before installation in new plant.

THE VALVES THAT WOULDN'T RETIRE

The Rockwell-Nordstrom lubricated plug valves shown above were two of dozens installed in 1930 on caustic lines at a process plant. When the plant was torn down in 1959, the valves were still in such good condition that they're being used on the same service in the new plant.

The above story is just one more example of the ruggedness of Rockwell-Nordstrom valves. Since they're sealed positively against leakage by pressurized lubricant and there are no exposed metal-to-metal seats, you get positive shut-off year after year. And, lubrication is preventive maintenance against the high cost of repairs, replacement and downtime. To get complete details on Rockwell-Nordstrom, the original and world's most complete line of lubricated plug valves, lubricants and accessories, write: *Rockwell Manufacturing Company, Pittsburgh 8, Pa.; Canadian Valve Licensee: Peacock Brothers Limited, Montreal, Quebec; Rockwell International S.A., Geneva, Switzerland.*

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ROCKWELL-Nordstrom VALVES

another fine product by

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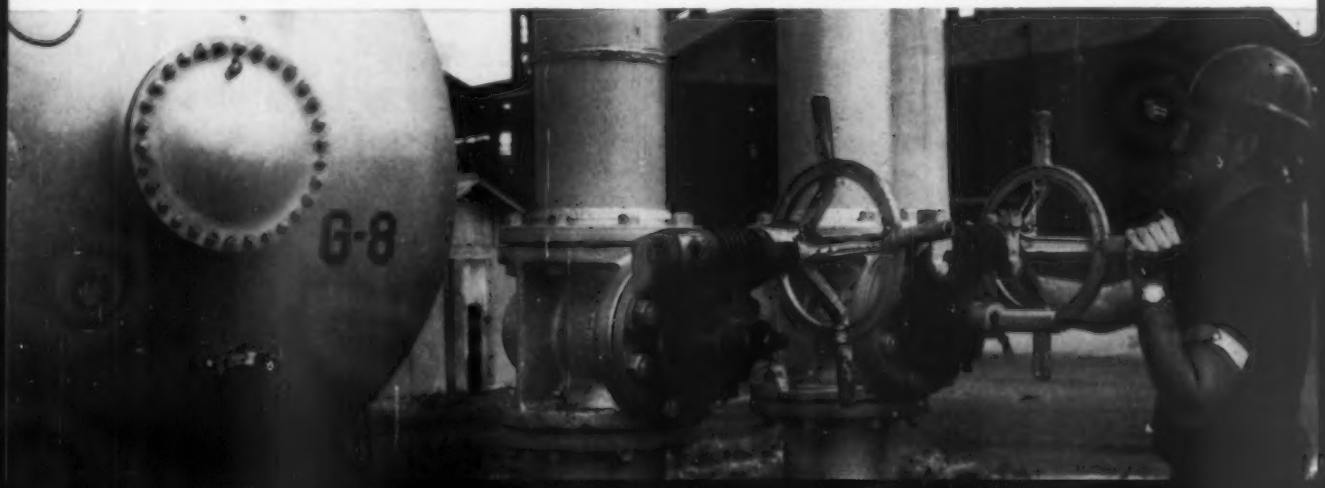
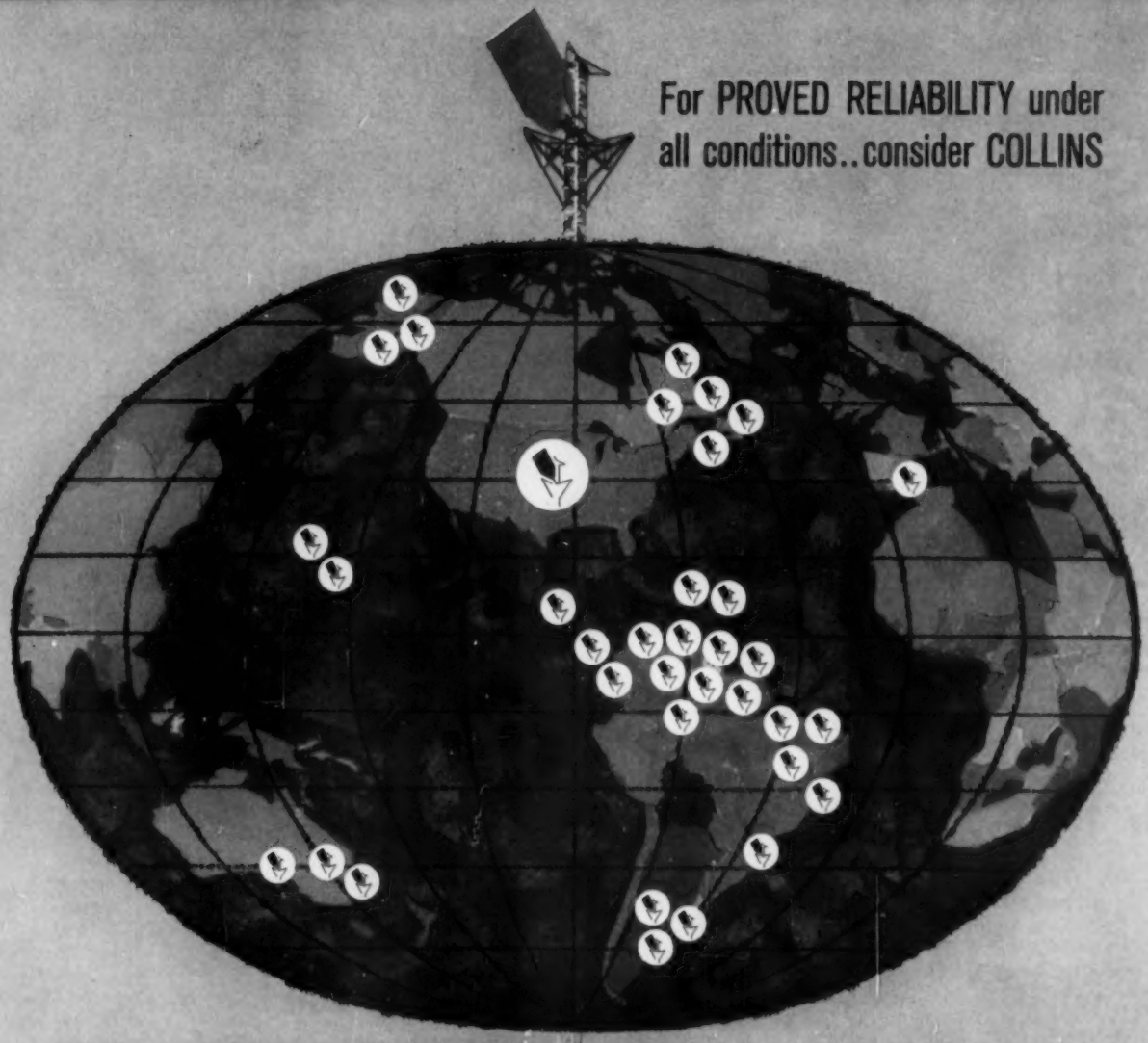


These gear operated Rockwell-Nordstrom valves have given many years of trouble-free service, positive shut-off on this refinery gas storage system.



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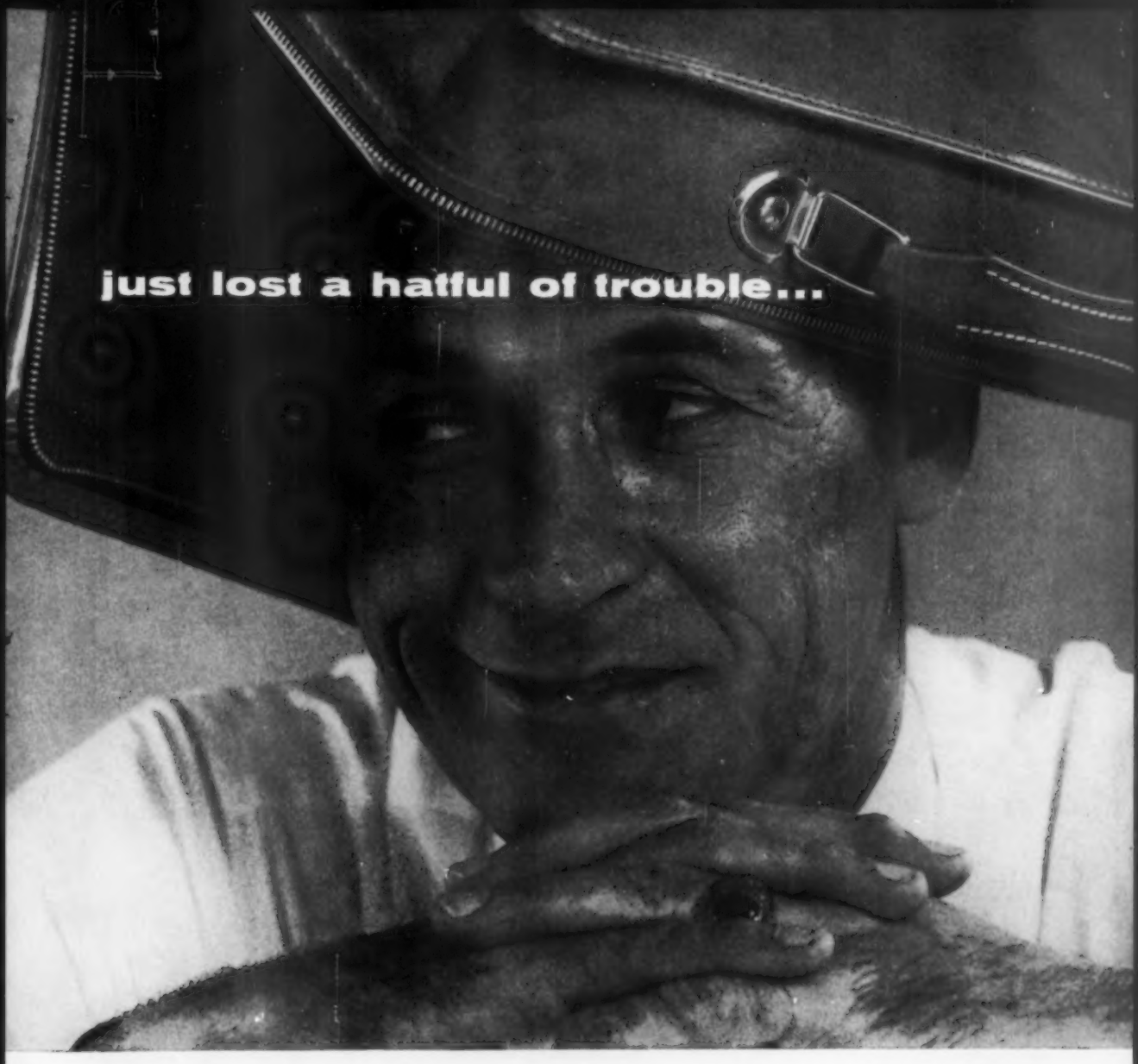

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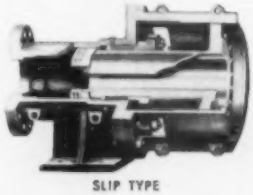
RAM-PAK



SLIP TYPE

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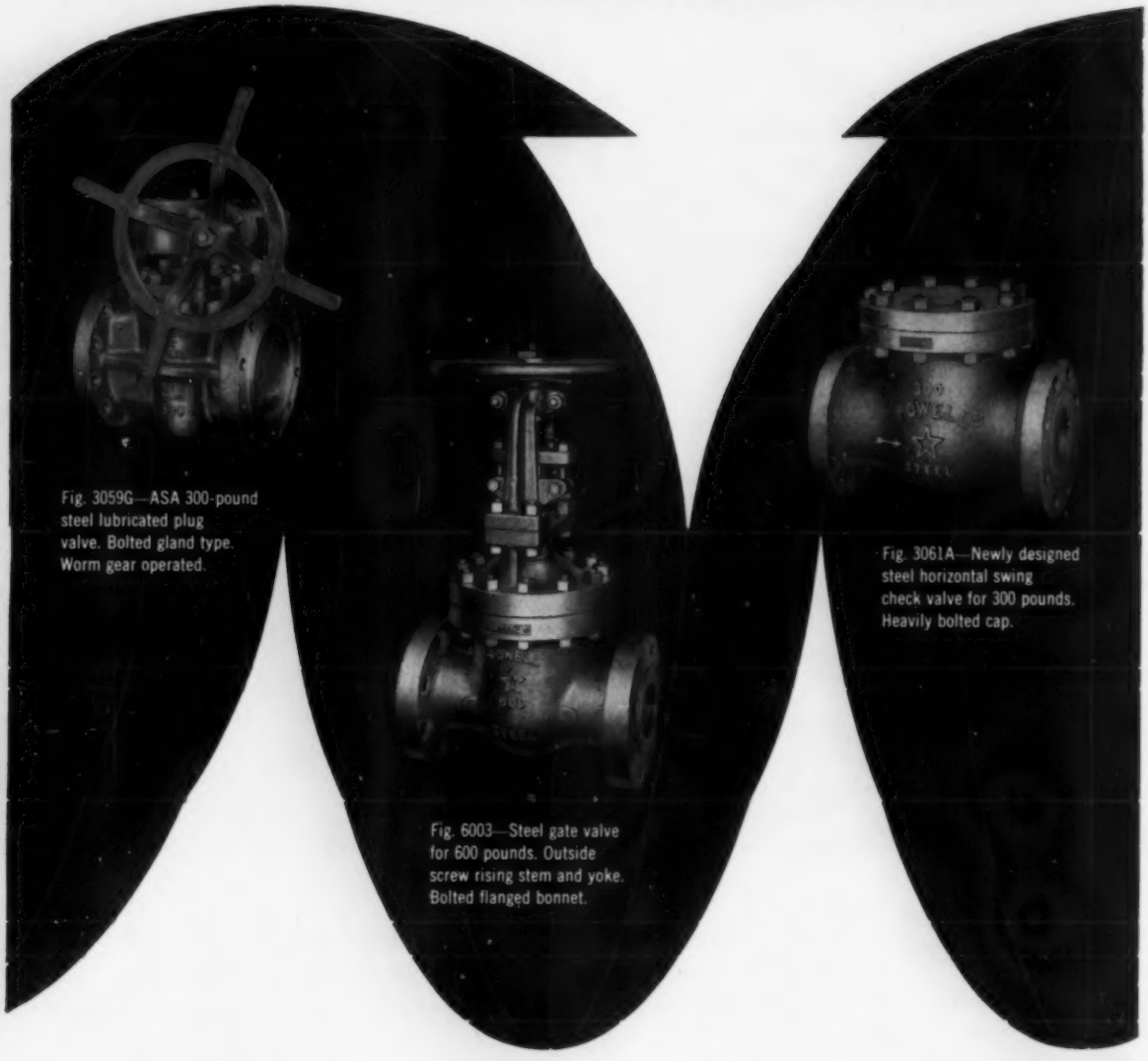

Fig. 3059G—ASA 300-pound steel lubricated plug valve. Bolted gland type. Worm gear operated.

Fig. 6003—Steel gate valve for 600 pounds. Outside screw rising stem and yoke. Bolted flanged bonnet.

Fig. 3061A—Newly designed steel horizontal swing check valve for 300 pounds. Heavily bolted cap.

Powell steel valves have been performance proven for more than a century in controlling the flow of fluids in refineries, petrochemical plants and storage facilities.

Also, there are Powell Valves in bronze, iron, pure metals and special alloys for handling water, oil, gas, air, steam and corrosive media. So whatever your flow control need may be, you can depend upon a Powell Valve to take care of it.

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and building a haul road

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GLOBAL NOTEBOOK

The Soviet Gas Goof

USSR suffers now because Stalin gave coal priority and natural gas reserves were not developed . . . Today the big push is on to expand this important energy industry

Charles L. Adams

UNDER PREMIER KHRUSHCHEV'S regime, the Soviet gas industry has been growing at an unprecedented rate. Year-to-year percentage gains in output are impressive—sometimes astronomic. And long-range goals call for total 1965 gas production (including casinghead gas and artificial gas) to be five times the 1958 level.

Nevertheless, a monumental blunder committed by Joseph Stalin before World War II has dashed Russian hopes of overtaking the United States in gas output during the foreseeable future. Nearly 30 years of Stalinist rule stunted Russian gas production. Today the industry is among the most laggard branches of the fast-expanding Soviet economy.

Russia is discovering in the gas industry what America found out to its dismay in the missile race: It is extremely difficult to catch up to a nation which not only had a long head start but is still running at high speed.

During 1959 — first year of the USSR's new Seven-Year Plan — gas output was one of the few major indices of Russian industrial output to fall below national goals. Targets for production of such important items as crude oil, coal, steel, pig iron, electricity, non-ferrous metals and machine tools were surpassed.

Russia produced 37.2 billion cu m (about 1313 billion cu ft) of gas in 1959, compared with 29.8 billion cu m (1052 billion cu ft) in 1958. Without closer examination, the 25 percent gain in gas output looked good alongside the 11 percent production increase for Soviet industry as a whole.

But in terms of absolute (physical) gain, by comparison with American output, and in the light of its own objectives, the Soviet gas industry had no cause for rejoicing. (See table.)

RUSSIANS CLOSING THE GAP?

		Gas Production (Billions cu ft)	Percentage Gain Over Previous Year	Absolute Gain Over Previous Year (Billions cu ft)	U.S. Margin Over Russia (Billions cu ft)
1956	Russia*	483	32	118	
	United States†	12,373	7	653	11,890
1957	Russia	713	48	230	
	United States	12,907	4	534	12,194
1958	Russia	1,052	48	339	
	United States	12,999	1	92	11,947
1959	Russia	1,313	25	261	
	United States	13,600	5	601	12,287

*Russian figures include artificial (manufactured) gas.
†Gross.

Last year, total Soviet gas production, including artificial gas, was less than 10 percent of American gross natural gas production. The gap between Russian and American output in other major branches of industry was far smaller.

For example, the USSR during 1959 turned out 70 percent as much steel, nearly 37 percent as much crude oil, and 34 percent as much electricity as the United States. Russia surpassed this country in producing coal and iron ore.

The Soviet Union has drawn up a master timetable for overtaking the United States in total industrial output by 1970. But the American gas industry during 1959 surpassed the USSR's maximum 1972 gas production goal of 320 billion cu m (11,296 billion cu ft).

A report delivered at the 21st Extraordinary Congress of the Soviet's Communist Party last year declared:

"U. S. industrial output per head of population is now more than double that of the USSR, and agricultural output is about 40 percent higher. How soon can we close this gap, draw level, and then surpass the USA in these indices?

"Rates of production growth are decisive. And the advantage of rates rests with the socialist (communist) economic system. Our mean annual industrial rates of growth since the Revolution have been 3 to 5 times higher than those of capitalist countries.

"We do not doubt for a moment that the mean annual growth in industrial output of 8.6 percent, designated in the Seven-Year Plan, will not only be achieved but also surpassed. Nor will capitalist countries stand still.

"In the next few years U. S. industrial production will presumably grow some 2 percent annually. That has been the rate of development in American industry in recent years.

"There is one more important thing we must bear in mind. In spite of its fairly low rates of economic growth, the USA was for a long time ahead of the USSR in annual physical volume of industrial growth. But that time is now past. In the last eight years the Soviet physical volume of growth for a number of key lines (steel, pig iron, iron ore, coal, cement, woolen fabrics) has, on the whole, exceeded America's.

"Thus a qualitatively new stage in the competition has opened in this respect as well. Today our country is ahead of the USA both in annual (percentage increase) rates and in annual

Contrasted Approaches to Natural Gas Development Ominous

THIS ARTICLE explores the delayed but currently all-out effort of the Soviet to develop its natural gas resources. We are perhaps indebted to Stalin that he held back development of gas energy in favor of coal, because "coal reserves were huge" and considered greater than oil and gas.

In the U. S. today there is a strong movement to follow the Stalinist economic line. Objective of the National Fuel Policy Commission apparently is to hold back natural gas development in favor of coal because of present estimates that we have more coal. (This has been conceded but estimates of oil and gas reserves have increased continually while estimates of coal reserve remain pretty steady.)

Instead of market place economics that would price natural gas according to its thermal efficiency, we have a utility-type pricing control by the Federal Power Commission that discourages development. (Price of natural gas equivalent of 1 bbl crude oil is 65¢ vs $2.94 for oil.)

The Soviet estimates that 1 kilowatt-hour of electric power generated from coal costs an average of 2 to 2½ times as much as when natural gas fuel is used. This from a country which presumably bases cost on efficiency. We have not seen a similar estimate for natural gas versus coal in the U. S. but the remarkable ability of electric distribution companies to hold down prices through a long period of rising costs probably is due chiefly to increasing use of natural gas, the more efficient fuel.

We have a choice: We can keep our price control of independent gas operators and stunt the exploration and development of our most promising energy resource.

Or, we can let a competitive market determine the most efficient use of each fuel.

There are footnotes to each of these choices. To the first choice there are sycophants who say natural gas is too precious for fuel and pessimists who say reserves are too limited. A free market would soon tell us how much gas was worth in our economy. If it is worth more it will be found. With all the energies — nuclear fission, sun rays, Athabasca sands, oil shales and oil — in competition, natural gas doesn't need the solicitude that its false flatterers would wrap it in to keep it from the harsh realities of the market place.

To the second choice, we add: Who is going to determine the best fuel for each use? The Congress? Washington bureaucracy? It must be based on price, controlled or free, and so far only natural gas prices are under federal control. We can make a good Stalinist decision and put every energy under government control (with the dangerous gamble of political planning of economy) or we can take our economic problem to the highest economic court ever established — the free competitive market place.

And where do you register your choice? At the White House. At the Senate and House. At the houses and apartments of those who are told their Congressmen have compelled the U. S. Government to keep their gas utility bills static and controlled.

Remember, too, that you do have a choice. That is the difference between Stalin's decision and yours. You don't have to be absolute ruler of a nation to have a choice.

THE EDITOR

physical growth of production. We go forward four times as fast, and we add more to our output each year.

"... by that time (1970)—or even earlier — the Soviet Union will rank first in the world both in physical volume of production and per capita output. That will be a historical world victory for socialism (communism) in its peaceful competition with capitalism in the international arena."

Coming in the wake of such a bold economic manifesto, the Russian gas industry's 1959 performance was a distinct disappointment to Soviet officials. Besides failing to meet its gas output goal last year, the USSR's rate of gas production growth fell off markedly and unexpectedly.

In both 1958 and 1957, Soviet gas output had soared 48 percent—nearly twice 1959's percentage gain. More important, 1959's absolute increase of 7.4 billion cu m was well below 1958's gain of 9.6 billion cu m.

In 1959, Russian gas production of 37.2 billion cu m (1,313 billion cu ft) compared with an estimated 13,600 billion cu ft in the United States. Thus since 1956 Russian gas output gained nearly 172 percent against a modest 10 percent for the United States in the three-year period.

But the absolute U. S. gain from 1956 through 1959 was 1,227 billion cu ft compared with 830 billion cu ft for the Russians. And the American gas production margin over the USSR widened from 11,890 billion cu ft in 1956 to 12,287 billion cu ft in 1959.

Obviously the Russian gas industry has been losing the real production race while winning the deceptive percentage game in spectacular fashion.

It now appears certain that the Soviet Union's 1960 gas output target of 60-65 billion cu m, set by Premier Khrushchev in 1957, will be missed by a rather wide margin. Late last year the goal for 1960 was revised downward to 53.2 billion cu m—43 percent more than in 1959.

To achieve the Seven-Year Plan objective of 150 billion cu m in 1965 (135-140 billion cu m of natural gas plus casinghead gas and about 2 billion cu m of artificial gas), Russia would have to increase total gas output an average of almost 19 billion cu m annually during the next six years.

The 1959 rate of gas production growth was less than half the required annual increase for the Seven-Year Plan as a whole.

Should the USSR fail to achieve its gas production goals during the remainder of the Seven-Year Plan, there will be serious repercussions in other branches of the Russian economy—especially in heavy industry. *Over 80 percent of Russia's gas production* in the 1959-1965 period *has been allocated for use as industrial fuel.*

Many open-hearth and blast furnaces, cement plants and thermal power stations are slated for conversion from coal to natural gas during the Seven-Year Plan. *The Soviets are counting on substantial increases in productivity to result from this changeover.*

Russia estimates that 1 kilowatt-hour of electric power generated from coal costs an average of 2-2.5 times as much as when natural gas fuel is used. By 1965, the USSR expects its electric power plants alone to consume 30-35 billion cu m of natural gas annually. Proportion of electric power produced with gas fuel will rise from 3.3 percent in 1956 to about 15 percent in 1965.

A sanguine if somewhat unrealistic view of Soviet gas production progress is provided in the foreword to a recent Russian book "Roads to Development of the USSR Gas Industry" issued by the State Scientific-Technical Publish-

ing House for Oil and Mineral Fuel Literature. It says:

"The American gas industry required 40 years to increase gas output from 10 billion cu m to 120 billion cu m. Our gas industry will accomplish this task in 10 years (1955-1964)."

But in more sober analyses of the situation, Russia's top economists, without mentioning names, leaves no doubt of their conviction that the big reason for the natural gas industry's present lag lies entombed in Red Square.

The USSR's State Planning Committee (Gosplan) now admits that Stalin "permitted errors in determining the structure of the nation's fuel balance." *The Stalin economic line*, once regarded as infallible, *held that development and use of coal should be given priority "because our proven coal reserves are huge, while our explored oil and gas reserves are small."*

According to Gosplan, Russian geologists were saying even before World War II that the USSR was "extremely rich in potential oil and gas reserves." These estimates, the committee sadly recalls, were ignored "although it has been proved that our country leads the world in such reserves."

In 1940, "because of this abnormal situation," known Russian natural gas fields were limited to the far-northern Komi Autonomous Republic, the Buguruslan district in what is now part of the "Second Baku" area between the Volga River and Ural Mountains, the western Ukraine, and the Caucasus. Proven Soviet "commercial" natural gas reserves in 1940 were only 15 billion cu m.

Intensified exploration since Stalin's death in 1953 lifted Russia's proven commercial natural gas reserves to 588 billion cu m in 1956 and 988 billion cu m in 1958. In 1959 reserves soared a record 501 billion cu m, largely as the result of faster-than-expected exploration of the huge Gazli field in the Bukhara-Khiva area of Uzbekistan and an upward revision of estimated reserves in the eastern Ukraine's Shebelinka field following a new survey.

Russia plans to add 396 billion cu m of gas to its proven reserves in 1960, bringing the total to more than 1,800 billion cu m. By the end of 1965, the USSR hopes to have at least 3,300 billion cu m in proven reserves despite sharply-rising consumption.

Soviet economists point out that the growth in proven natural gas reserves (excluding casing-head gas) was five times production between 1946 and 1950, 16 to 1 in the 1951-1955 period, and averaged 11 to 1 in 1956-1957. A discovery-use ratio of at least 10 to 1 appears assured for 1958-1960.

Besides Gazli and Shebelinka, new natural gas discoveries in the postwar period (most of them developed only after Stalin's death) include such large fields as Stepnovo (in Saratov Province east of Volga), Northern Krasnodar (east of Azov Sea), Berezovo (northwestern Siberia), and Irkutsk and Ust-Vilyui (eastern Siberia).

Russian long-range planning calls for proven natural gas reserves to be at least 20 times production at all times. (U. S. is 19 times.)

Biggest increase percentage in Soviet natural gas production under the new Seven-Year Plan will be in Uzbekistan, whose Gazli field is said to be the largest in the world. From only 172 million cu m in 1958, Uzbekistan's natural gas output is slated to reach 18.3 billion cu m in 1965.

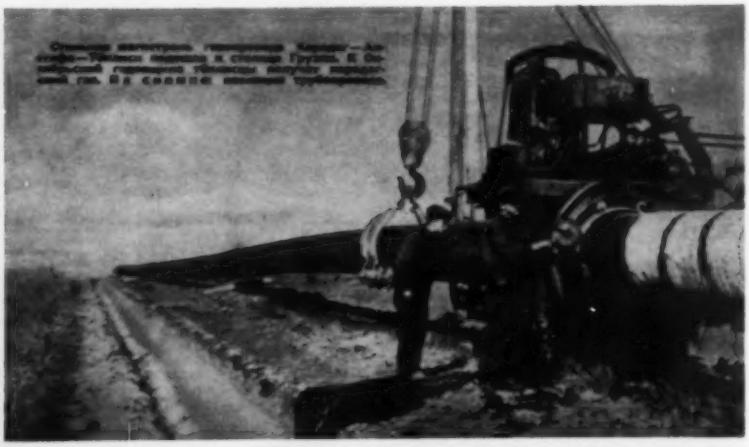
In the same period, production in the Russian Soviet Federated Socialist Republic (which embraces most of the USSR) will rise from 10 billion to 72 billion cu m; in the Ukraine from 10 billion to 30 billion cu m; and in Azerbaijan from 3.5 to 10 billion cu m.

Russian geologists estimate that the Soviet Union's "potential" natural gas reserves total 20,000 billion cu m. The State Planning Committee says long-term expansion of the nation's natural gas industry should be based on a 15,000-20,000 billion cu m potential.

Russia has ordered a substantial increase in exploratory drilling to maintain a high discovery rate. During the Fifth Five-Year Plan (1951-1955), exploratory drilling for gas accounted for only 9.5 percent of total exploratory drilling for both oil and gas. In 1956 the percentage rose to 15 percent and in 1957 to 21 percent.

In 1959-1965, plans call for the proportion of exploratory drilling for gas to average 30 percent. Total volume of "deep" exploratory drilling for gas scheduled during the seven years was recently raised to 15 million meters (49,200,000 ft).

Helicopter supplies Russian geological exploration team in Kyzyl-Kum desert of Uzbekistan, where the USSR's largest gas field has been found.



Insulating crew at work on Karadag-Akstafa-Tbilisi gas pipeline, completed last year. The system carries gas from Karadag field on the Caspian Sea coast through the Caucasus Mountains to the capital of the Georgian Soviet Socialist Republic.

SPECIAL REPORT TO CATERPILLAR OWNERS:

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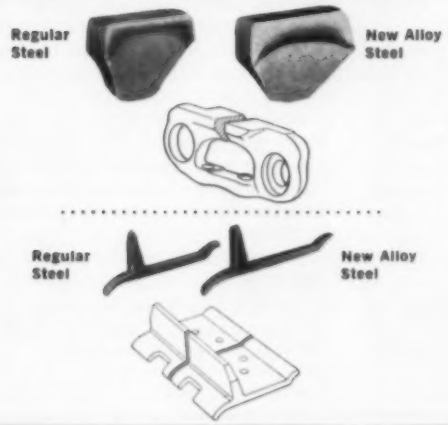
...cost less per hour

OPTIONAL TRACK GROUPS

up-date D9 or D8 Tractors for longer undercarriage wear

Now, two types of track groups are available for older model D9 and D8 Tractors . . . regular and optional, allowing you to tailor your undercarriage parts to meet job conditions.

Lighter tones at top of etched cutaways show depth of special hardness in wear zones.



REGULAR track parts are made from durable steel. They're heavy-duty, long-lived, special-hardened to resist wear.

OPTIONAL track parts are equivalent to those used on current production model tractors. The links and shoes are made from Caterpillar's new alloy steel that is hardened much *deeper* than regular steel. Link rails are hardened twice as deep. Shoe grousers are hardened 400% deeper. The new alloy steel also provides greater strength with more impact resistance.

MORE METAL WHERE IT COUNTS. Optional components are king size. Every part is beefed up and made bigger with more *hardened* steel in wear areas.

BORALLOY "HUNTING TOOTH" SPROCKETS are another new feature of the optional groups. Every other tooth is used in one revolution, alternate teeth being picked up the next revolution. This alternation means that teeth contact the bushings only *half as many times* as do regular sprocket teeth. More important are the teeth themselves—they're *machined* for exact fit with the big bushings. This greatly extends bushing life.

COMPARE regular and optional track components:

	Pitch	Pins O.D.	Bushings O.D.	Track shoe bolts and nuts	Sprocket
D8	regular 8 inches	1 3/4 inches	2 3/4 inches	3/4 inch	14 tooth
	optional 9 inches	2 inches	3 inches	7/8 inch	25 tooth
D9	regular 9 inches	2 inches	3 3/16 inches	7/8 inch	28 tooth
	optional 10 1/4 inches	2 1/4 inches	3 3/8 inches	1 inch	25 tooth

HOW MUCH MORE LIFE? Variation in the length of track life occurs because components have different wear rates under various soil and job conditions. In sand, pins and bushings wear faster. In rock, shoes and links wear faster.

ON-THE-JOB TESTS confirm that the new optional track components are giving up to 40% more life than the regular parts. On many applications, you can expect even greater wear life.

CORRECT TRACK GROUP SELECTION IS IMPORTANT. It depends on job types and conditions. Let your Caterpillar Dealer analyze your track needs. He'll recommend the correct components to help you get maximum life at the most reasonable investment. Call him soon.

SERVICE TIP: **FREE!** Handy reference for ordering track options. "New Options for D9 and D8 Tractors" includes part numbers that are used to adapt to your older models. Pick up a copy at your Caterpillar Dealer's.

CATERPILLAR

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Caterpillar Tractor Co., General Offices
Peoria, Ill., U.S.A.

Construction work underway at new natural gas liquids plant in Bashkiria.

During 1960 the drilling program calls for 605 exploratory gas wells totaling 1,295,000 meters (4,248,000 ft).

Average "effectiveness" of exploratory drilling for gas in 1951-1955 was about 290,000 cu m of commercial reserves found per meter of hole. In 1957 it was 220,000 cu m of reserves.

Russia concedes that such high returns cannot be maintained since they were achieved by "limiting exploration to the most promising areas." It hopes, however, to get 200,000 cu m of commercial reserves per drilled meter of exploratory well in 1959-1965.

To do this, the State Planning Committee has called for a sharp improvement in drilling efficiency and better equipment. It says that rigs must be moved from site to site "in large blocks" (with minimum disassembly); new mobile equipment must be designed and manufactured in quantity; greater use must be made of turbodrills and electric drills; average hole diameter must be reduced and the quality of drill pipe for deep wells raised; and many repair bases must be set up.

One of the principal reasons for Russian failure to meet gas production goals in 1959 was the lag in pipeline construction and utilization.

Russia placed about 2298 miles of gas trunkline in operation during 1959 – a new record. In the same period, the United States built about 7700 miles of gas pipeline.

Total length of the Soviet Union's gas transmission system at the end of 1959 was around 8500 miles compared to 170,000 miles of transmission pipelines in the U. S. A. (Total transmission and distribution lines in U. S. are 595,000 miles.)

New gas pipelines completed during 1960 is expected to total about the same as last year. Trunkline construction scheduled under the entire Seven-Year Plan is 26,000 kilometers (16,146 miles), bringing the total Russian gas transmission system to about 22,350 miles in 1965.

But, as the Russians admit, completing a pipeline and putting it into full operation are entirely different matters. A State Planning Committee official, V. A. Kalamkarov, declared recently:

"Our experience in 1959 and preceding years shows that a fundamental factor holding back still faster development of the gas industry is the unsatisfactory use of equipment—primarily compressor installations for stations along trunk gas routes. Our goal for gas production in 1960 is predicated on the assumption that all gas turbine equipment already delivered to and set up in compressor stations, and all equipment scheduled for delivery this year, will operate without interruption so that completed gas trunklines will be utilized at full capacity."

Russia plans to start laying pipe on its largest-capacity gas transmission system during 1960. It will consist of two, parallel, 40-in. lines, each extending 1300-1400 miles from the enormous Gazli field in Uzbekistan northward to the Ural Mountain metallurgical centers of Chelyabinsk and Sverdlovsk.

Significantly, Russia has changed the original routing of the Gazli-Chelyabinsk-Sverdlovsk gas lines so that, instead of going directly north along the eastern shore of the Aral Sea, they will be laid around the sea's western shore, then head northward. This indirect course — 150 miles longer — will take the system through the Barsuki desert, northwest of the Aral Sea, where, it is believed, the Soviet Union has a "rocket city" with launching pads for ICBMs and space vehicles.

Besides appropriations for drilling, development and pipelining, large outlays have been provided by the Russian gas industry for natural gasoline plants at Karadag and Siazan in Azerbaijan, Minnibaevo in Tataria, Mukhanovo in Kuibyshev, Shkapovo in Bashkiria, and Dolina in the western Ukraine.

Total capital investment in the Russian gas industry during 1960 will be 15.4 percent more than in 1959. ★ ★

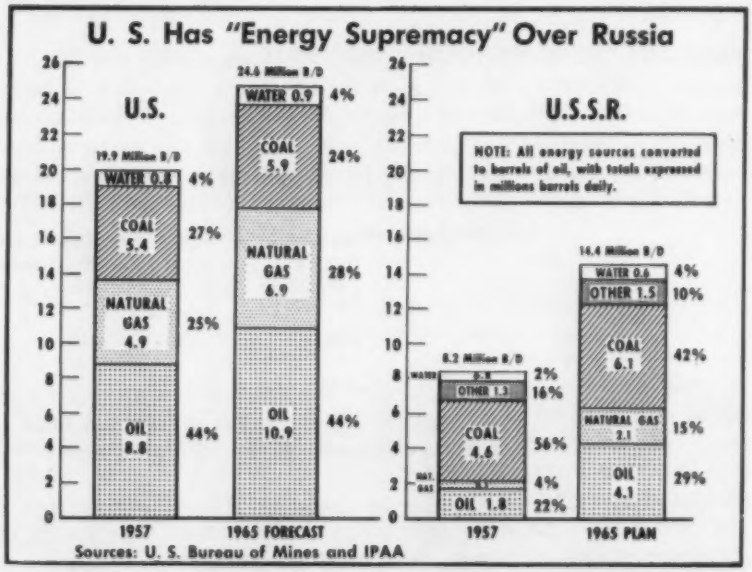

Chart compares American and Soviet energy production, and projects the comparison to 1965. Russia is second to the U. S. in total energy output, but is behind at least a dozen Free World countries in per capita energy use. The Soviet recently announced a vast new program to expand energy output with a 1965 goal of 14.4 million barrels daily. Despite these programs, America can maintain "enery supremacy" for the foreseeable future, says the Independent Petroleum Association of America. Petroleum fuels, oil, and natural gas, provided 69 percent of U. S. energy needs in 1957, and by 1965 will be filling 72 percent of our requirements.

USSR Oil Exports Rise

Recent increases are spectacular but energy consumption in Russia's Economic Plan will not permit expanding exports unless politics interfere

INCREASING EXPORTS of Soviet oil and oil products have gained considerable attention in the last two or three years. Currently they amount to a very small percentage of world commerce in petroleum but surplus capacity in producing countries turn emphasis on the rising trend.

In the table published here the Bureau of Mines has translated into barrels per day the USSR's statistical report for 1958. The total figure is only 131,000 bbl per day according to this record and estimates of 1959 ran to 250,000 to 260,000 bbl a day, virtually double the year before.

Several trade agreements arrived at in 1959 promise a still expanding Soviet oil export business in 1960.

The question is, can the USSR throw a spanner into the already precariously held prices of international oil trade? It is more or less understood that Russian prices are set politically rather than economically and cheap oil might spell political advantage to the Communists.

(In a political economy it is doubtful if actual costs can be accurately calculated. The Soviet uses prices of free world commerce for most of its trade.)

J. A. Cogan, vice president, Imperial Oil, said in a speech last year that Russia gave "considerable recognition to economic considerations" although its trade agreements were politically motivated.

The deal with Japan for 100,000 tons of crude oil in 1960 is for $16 per ton, which is about $2 a bbl or more—how much exactly depends on gravity which was not stated in the reports we have.

Percentage-wise, the increase in Soviet oil exports is large but, as Mr. Cogan estimated, in 1959 they were less than 2 percent of Free World oil trade. Most of this was in the Eastern Hemisphere. Cogan said about 25,000 bbl per day was exported to the Western Hemisphere. Argentina was the chief importer of Russian oil in 1958 and in 1959 but the volume is insignificant.

The 1965 Plan of the USSR calls for greatly increased consumption of oil and gas with less use of coal. In his paper for the API, November 10, 1959, Theodore Shabad, New York Times, included this table of Soviet energy consumption in percent of total.

USSR — EXPORTS, 1958 (Thousand barrels).

	Crude petr.	Gasoline	Kerosine	Diesel oil	Fuel oil	Lubricants	Paraffin	Total
FREE WORLD:								
Argentina	4,885	—	434	1,361	—	—	—	6,680
Uruguay	806	133	—	394	233	—	—	1,566
Austria	—	—	—	—	—	—	2	2
Belgium	—	—	—	—	485	—	—	485
Denmark	—	—	—	1	254	—	4	259
Finland	—	270	215	2,704	2,166	36	3	5,394
France	1,315	1,245	—	1,960	801	—	—	5,321
W. Germany	—	—	—	2,986	600	—	—	3,586
Greece	—	—	546	364	1,523	—	—	2,433
Iceland	—	367	—	1,333	735	—	—	2,435
Italy	7,452	—	—	8	352	—	12	7,824
Netherlands	—	—	89	413	236	—	5	743
Norway	—	—	—	97	964	—	2	1,063
Portugal	359	—	—	—	—	—	—	359
Sweden	—	—	68	2,290	3,685	—	9	6,052
United Kingdom	—	—	—	19	9	222	17	267
Yugoslavia	2,708	48	—	15	—	—	1	2,772
Syria	—	54	—	1,294	605	—	—	1,953
Afghanistan	—	267	27	34	2	2	—	332
Algeria	—	—	—	283	—	—	—	283
Japan	80	—	—	—	—	—	—	80
Egypt	9,659	85	1,362	768	2,141	—	—	14,015
Morocco	218	—	—	—	—	—	—	218
Tunisia	—	—	—	—	119	—	—	119
TOTAL Free World	27,482	2,469	2,741	16,324	14,910	260	55	64,241
COMMUNIST COUNTRIES:								
Albania	—	—	—	7	—	29	—	36
Bulgaria	—	1,478	315	1,238	44	153	7	3,235
Czechoslovakia	10,109	670	—	230	—	—	—	11,009
E. Germany	8,037	—	—	—	—	27	97	8,161
Hungary	7,881	—	—	—	349	22	—	8,252
Poland	4,021	4,247	303	—	535	[1]55	26	9,187
Rumania	—	—	—	—	—	6	—	6
Chinese People's Rep	4,879	5,443	2,579	4,945	—	1,390	4	19,240
N. Korea	—	1,111	53	448	43	155	—	1,810
Mongolia	—	300	2	164	—	38	—	504
Vietnam	—	125	75	36	—	8	—	244
TOTAL C. C.	34,927	13,373	3,327	7,068	971	1,883	134	61,684
Unaccounted for	3,603	245	520	96	448	[2]38	[2]3	4,953
GRAND TOTAL	66,012	16,088	6,588	23,488	16,329	2,181	192	130,878

[1]Petroleum coke.
[2]Includes small quantities exported to each of several countries in above listing.
SOURCE: "Vneshnyaya Torgovlya SSR Za 1958 God: Statistichiskiy Objor" (Foreign Trade of the USSR in 1958: a Statistical Survey).
Translation: European Section, Division of Foreign Activities, Bureau of Mines. The original statistics (all in metrics units) are converted into the English system.

TABLE 1. Structure of Soviet Energy Consumption (in percent of total)

	1958	1965 Plan
Coal	58.1	41.8
Crude oil	25.7	32.7
Gas	5.4	17.0
Peat	3.2	2.6
Firewood	4.0	2.4
Oil shale	0.7	0.7
Water power	2.9	2.8
	100.0	100.0

He mentions also the sharp reversal of Soviet economic policy that now gives priority to oil and gas development, stabilizing coal development. The plan is to increase oil and gas development in the energy picture to 50 percent while coal is scheduled to drop to 42 percent. In the U. S. oil and gas presently accounts for more than two-thirds of energy requirements.

If the Soviet economy progresses at any rate close to its plans consumption of oil and gas may easily rise faster than production so it could be at the cost of domestic demand if exports continue to increase.

Threat of dumped Soviet oil on world markets sounds pretty feeble for the near future. The greater danger is Red influence in present or potential oil-producing centers outside the Soviet Union in the long-term picture. ★ ★

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For Oil Field Applications

6000 psi
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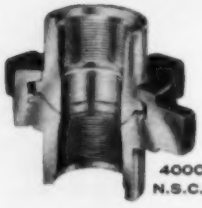
. . . quickly indicates pressure rating and type of seat

CM Hi-Pressure

Handlebar UNIONS



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Fast acting! Rapid make and break! Color coded for quick identification! Everything about the new CM "Hi-Pressure" Handlebar Unions is designed to give easy, snappy service in the oil processing field . . . where time counts. With a metal-to-metal seat, the CM "Hi-Pressure" Handlebar Union withstands 4000 p.s.i. With the new "O" ring, this union offers a *dual* seal of rubber-to-metal and metal-to-metal with a rating of 6000 p.s.i. Available in 2" size, these unions have wide application in the petroleum industry. Offer the newest and the best on the market today . . . the CM "Hi-Pressure" Handlebar Union!

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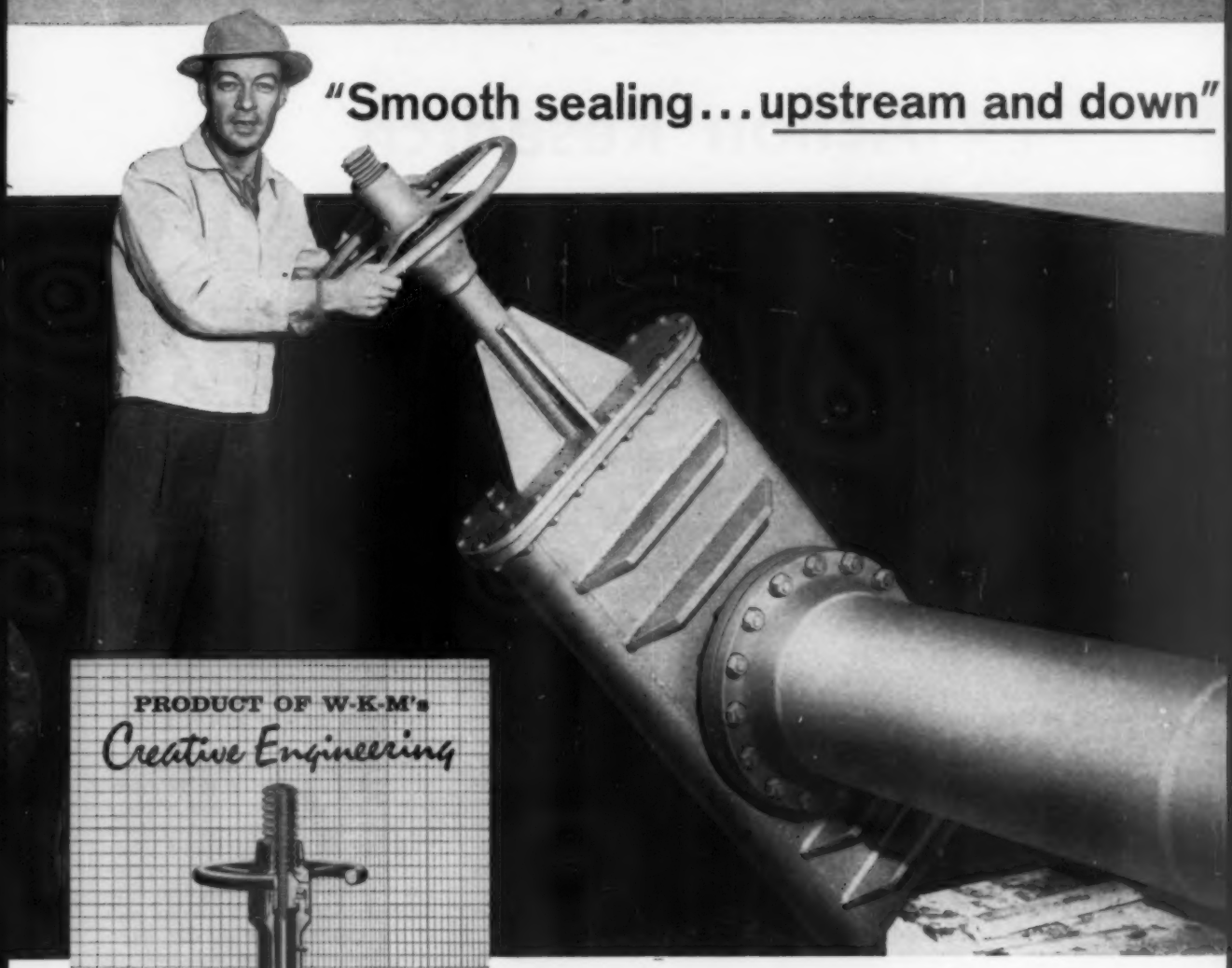

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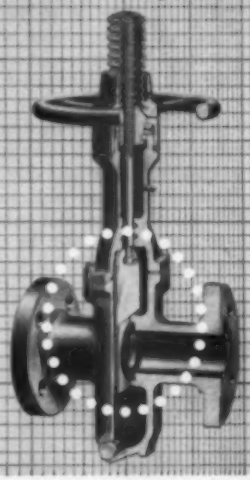

FLOATING SEATS MAKE THE SEAL

Seats are specially formulated rubber molded to a hardened steel insert. They float against the gate. When the gate closes, line pressure forces the gate against the downstream seat making a tight seal. The upstream seat maintains its seal against the gate for an upstream seal. The valve provides a tight seal under little or even no line pressure or under vacuum conditions.

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W-K-M's new Pressure Sealing Gate Valve

Almost without effort . . . you get a tight seal on *both* sides of the line. The secret? A unique seat design that puts line pressure to work *for* you. The greater the pressure, the tighter the seal!

Seats automatically adjust for wear . . . automatically relieve excessive body pressure. And on-the-line overhaul is easy.

Specify W-K-M's economical new Pressure Sealing Gate Valve for pressures to 720 psi (cwp) and temperatures to 250° F. Sizes 2" through 30". *At leading supply stores everywhere.*

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Action Research for Management

Self-analyses must come before managers can improve, but where do you get the facts on which to evaluate management?

Mark D. Poteet

A GOOD POKER PLAYER plays to win. He figures the averages, knows his competition and senses exactly what to do and when to do it.

It is much the same way with a company, they must plan ahead in every area and in no field is this more important than in personnel. Company growth depends on it. For unless a business has people with skill, imagination and a capacity for leadership, its other plans may well be worthless. It is with this in mind that I want to ask you a question:

"What kind of a leader are you?"

That is a question we have been asking our management people, and when I say management people I mean from the president of the company to the front-line or firing-line supervisor. There are several ways you can determine what kind of a leader you are. Some may be better than others and we believe we have one of the better ways to find out what kind of leaders our management people are.

There is, as you know, a lot of evidence that productivity is largely reflected in the reaction of people to management. People often spend more of their waking hours with their immediate bosses than with anyone else, so you can see how important it is for them to want to do the jobs assigned them since management's job is to get results through people.

It is only by developing and training management personnel that we are able to improve productivity of all employees.

Personal Inventory

You might call what we have been doing in Cities Service Oil Company "Action Research." Unless a man is jarred out of his customary ways, he will not give up the beliefs and attitudes of a lifetime. When executives take part in this personal inventory and fact-finding inquiry the very circumstances that the findings are a result of what they have asked for inspires them to change their attitudes and subsequent behavior.

We have called this program as we presented it a "Human Relations or Check List" conference. One way of determining what kind of a leader you are is to ask your boss. Well, maybe you don't want to know that badly and you might not like what he had to say. Or again, you can ask those you supervise "What kind of a leader am I?" Well, do you think they would tell you face to face? Some might be completely honest with you while others would hedge for fear of hurting your feelings. After all, they have to get along with you.

With all of this in mind, it was decided to use the Check List. What this check list does is give the executive a look at how he appears to those he supervises. This check list is composed of 38 questions covering qualities of a good leader and is headed up this way, "Does Your Supervisor Do These Things?" and the questions can be answered "Yes" or "Should Be Improved."

After a preparatory conference is held, a manager is asked, "Would you like to find out what kind of a leader you are?"

He can participate in this or not, whichever he decides. With the exception of two or three people within a few months of retirement, everyone in Cities Service has participated. There was no pressure, however, put on anyone to use this particular method. Next the supervisor is given a form for each of the employees he directly supervises, together with an addressed and stamped envelope so that when the employee checks the form he can put it in the envelope and mail it directly

SIX STEPS IN MANAGEMENT RESEARCH

1. Manager gives check list on himself to those he supervises.
2. Employees send check lists to management consultant.
3. Confidential analysis is made by consultant.
4. Analysis is sent direct to the supervisor checked.
5. Consultation with his boss if he requests it.
6. Composite of all check lists supplied to company.

Payoff —

(1) Manager sees himself as employees see him.

(2) Company finds areas in which management needs development.

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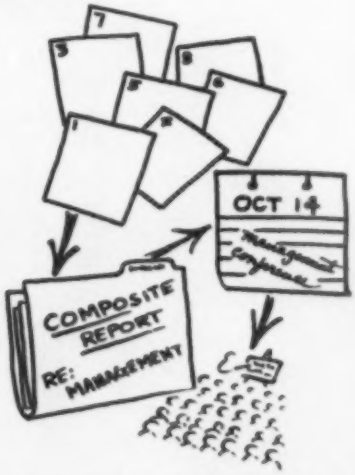
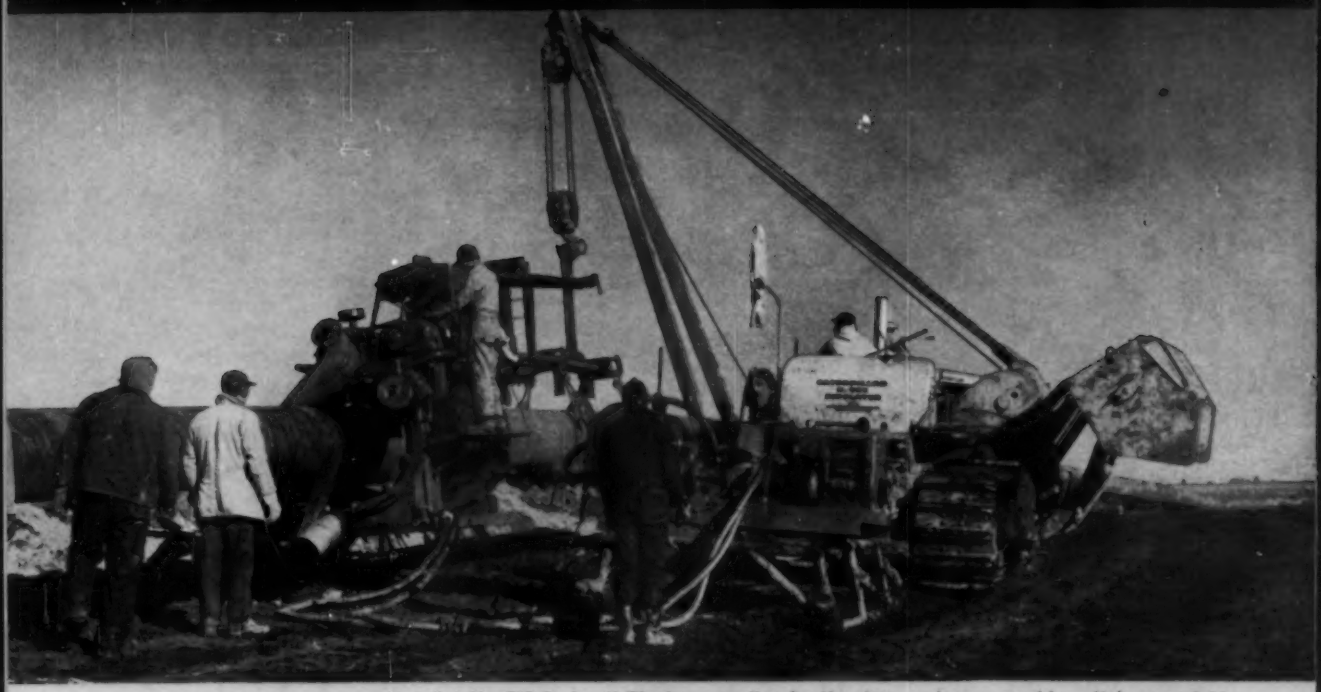


6. Composite of all check lists supplied to company.

TOUGH WINTER JOB WITH CATERPILLAR'S NEW



New Cat No. 583 Series H Pipelayer cradles for the dope and wrap machine. It is one of 14 Caterpillar-built rigs used on this spread by Engineers Limited Pipeline Co., El Cerrito, California.

New Cat No. 572 Series D Pipelayers handle 26-in. pipe. Production on the 138-mile project averaged 8000 to 9000 feet a day.

---EASIER EQUIPMENT

New Cat D9 Series E Tractor with Kelley Ripper manufactured by Crutcher • Rolfs • Cummings, Inc., rips through frozen ground. The D9 also handled clearing and backfilling jobs.

You expect problems on any pipeline job. And this one, from Rossville, Illinois, to White Pigeon, Michigan, is no exception. Engineers Limited Pipeline Co. has the contract for laying 26-in. pipe on this 138-mile stretch for the Trunkline Gas Co. of Houston, Texas. To push the job through, Engineers Limited set up an equipment spread on each end of the line—*100% Cat*.

The job started in December under severe winter working conditions. Frozen ground presented a digging problem. When it thawed, there was a drainage problem in areas with high water levels. Cat equipment on the western spread included a giant new D9 Series E Tractor with Kelley Ripper ripping the frozen ground in one pass . . . a new No. 583 Series H Pipelayer alternating between lowering and wrapping duties . . . five new No. 572 Series D Pipelayers with cradling and lowering-in assignments . . . and D8 and D7 Tractors.

Have you seen the new pipelayers?

New model or old-timer, Cat pipeline rigs get tough jobs done in a hurry. But to know what *performance* really means, look at the three new Cat-built Pipelayers—they incorporate advances in design and manufacture that increase your production and lower your operating and maintenance costs. They are briefly described here, but for complete information, see your Caterpillar Dealer. Learn about the giant strides in progress made in the three newest Cat pipeline rigs.

Caterpillar Tractor Co., General Offices, Peoria, Illinois, U.S.A.

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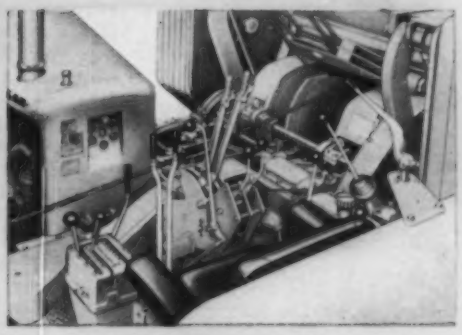
MODERN, HEAVY-DUTY PIPELAYERS FOR THE HARD WORK

3 NEW CAT-BUILT PIPELAYERS



No. 583 Series H

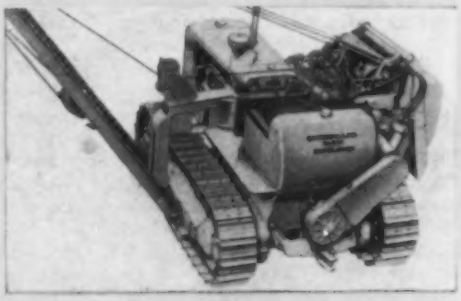
235 HP **137,000-lb. lift**

Now optional on the No. 583 – Power Shift Transmission! Big boon to any operator, it gives the No. 583 new finger-touch control, split-second gear changing . . . new precision control even in the toughest terrain . . . new top efficiency in all speeds and working conditions. The heaviest pipe jobs can now be handled even faster with the No. 583 with Power Shift Transmission! And the closely-retractable counterweights and good machine balance under load make the No. 583 champ of any job.

No. 572 Series D

140 HP **86,000-lb. lift**

A new Turbocharged Cat Engine gives the new No. 572 a 9% increase in power over the former model. The most modern pipelayer in its class, it has such advanced Caterpillar features as lifetime lubricated rollers . . . the dry-type air cleaner, which removes 99.8% of all airborne dirt from engine breathing . . . and many others. It's the "take charge" machine for handling 26-in. pipe with capacity left over.



No. 561 Series B

93 HP **38,800-lb. lift**

A new power plant that delivers 93 flywheel HP is designed for high torque at slow speeds, long life under heavy loads. The No. 561 is available with hydraulically-controlled counterweights or stationary arrangements for a wide range of lifting capacities. A new cockpit provides more comfort, easier control. Other features are the exclusive Cat oil clutch . . . hydraulic track adjusters that permit track adjustment with the easy stroke of a grease gun . . . and, of course, lifetime lubricated rollers. This new rig can handle more of your jobs with ease, speed and profit!

The Author

Mark D. Poteet is Coordinator Management Development, Industrial Relations Division, Cities Service Oil Company, Bartlesville, Oklahoma. Born and reared in Springfield, Missouri, attended both elementary school and college there. He belongs to American Society of Training Directors, Kiwanis Club, American Legion, serving on Committee on Training, API, Refining Division and Production Division. With Cities Service four years, he served in the Purchasing Department as buyer before present position. Formerly he was with Ajax Pipe Line Corporation and Cherokee Pipe Line Company.

to a consulting firm in New York City.

The manager passes the form out to each employee personally wherever possible, telling him that he hopes he will help him by giving his frank opinion in order that he might improve as an executive.

This firm tabulates the results on each and makes up a composite report and mails it direct to the address the supervisor has indicated he would like the results returned to. Note — he is the only one in the company who sees the results.

Confidential Report

We stress the confidential nature of this report to both the manager and the employee for just as it is voluntary for the supervisor to pass out the form it is voluntary on the part of the employee to fill the form out. The employee was impressed with the idea that no one in the Cities Service organization sees the form after it has been filled out by him. There is no opportunity for anyone to know what he says or checks on the form. In addition we ask the consultant to change the wording on the remarks portion of the form so as to hide more effectively identity of an individual.

What Is the Payoff?

Now you may be asking yourself, "Just what is the payoff in a program of this type for Cities Service, since they do not see the report on the supervisor?"

Here is what we believe — that if you are to get good results through others you need to know how they feel about you. This being the case, really no one but you can do anything about this. You must have a desire to change and improve. There is not really any good reason, then, why anyone other than you, the supervisor, should see this report. Another payoff to this program is that we receive from the consulting firm a composite report on the groups so we can conduct a series of conferences in each location composed of from 30 to 60 management people.

After we receive a composite result on the group, we compile a report covering all of our supervision throughout the company and this sifts out areas in which further management development training is required.

Pinpoints Needs

We have begun to try to take care of some items checked as needed improvement. The first suggestion came from employees. They said they wanted to know how they appeared to the boss just as he was learning how he appeared to them. Another area we found supervisors needed improvement was communications to employees. Now we are holding communications conferences with all of our supervisors discussing the various phases of communication — the written word, the spoken word, how we communicate, what we are to communicate, and case studies and role-playing communications.

We have been pleased with the enthusiasm that has been evidenced in this check list program by both management and employees. We feel one very important factor in the acceptance of this program was that we started with the president and the board of directors of the company, then worked our way down through the ranks of management to the front-line supervisor.

The composite report received by the supervisor is strictly confidential and what he does with the report is up to him. We do, however, offer to counsel with him after he receives the report, if he requests such an interview. The first year about 50 percent requested interviews. Of these about half the reports were very good and the other half indicated improvement needed. In this interview we discussed ways in which they might improve.

Our check list is a patented form supplied by the Gus W. Campbell Associates consulting firm. We do not feel at liberty to distribute these forms but have prepared this listing of 10 items checked most frequently by employees as needing improvement on the part of their boss: Does your supervisor —

1. Makes frank appraisal of employee's work and keeps them informed as to how they are doing?
2. Keeps his people well informed of objectives and results of the company and of the department?
3. Gives instructions clearly and concisely?
4. Trains employees in how to do their work?
5. Shows that he knows and understands the people who work for him?
6. Gets all the facts before making decisions?
7. Expresses himself well?
8. Makes decisions promptly?
9. Makes it easy for employees to ask questions?
10. Shows that he understands the job he supervises?

Some of the other questions were: Does your supervisor—

Treat employees fairly and impartially? . . .

Keep promises? . . .

Show interest in guiding and helping people? . . .

Welcome suggestions from his employees? . . .

Listen sincerely and sympathetically? . . .

We have begun to improve the first two items listed on the card and it is our intention to assist our supervisors on the other questions as time permits. We realize the broadside approach will not suffice so we keep to personal counseling with the individual.

As you might expect, there are superfluous as well as conflicting questions due to the fact that all employees are checking the forms from vice presidents to oil field roustabouts, refinery personnel and all the various divisions of an oil company throughout our operating areas. Also, what might be important to people in West Texas might not even be mentioned by people in Chicago, Canada, or Bartlesville.

We do believe sincerely that human relations are important regardless of the level of jobs or the location. We find our check list a means of helping human relations keep up with technical advances in our industry. * * *

ARE WE SOFT?

"lazy, satisfied"—can this be us?

Dr. Donald S. Clark

An indictment of the famous "American Way of Life" as lived today . . . Is it too late to change?

THE AMERICAN PEOPLE are not getting soft, they are already soft.

They lack firmness or strength of character.

We have degenerated from a hard working, progressive, high quality product and service nation of people to one that is lazy, complacent, selfish, and satisfied in giving and receiving poor quality services and products.

This condition may well be associated with the high standard of living that we have attained. We have come to the point where a very large portion of our people enjoy the benefits of modern technical developments. Life has become much easier on the whole, which has contributed to this attitude of complacency.

We should not, of course, return to the horse and buggy days, but we should not allow the conveniences of modern times to lead us into disregard for perfection.

The deterioration in the quality of services becomes evident in many stores. The salesperson is not really interested in serving the customer, and does not seem to care whether or not a sale is made. He or she is there to collect a pay check.

There are endless examples of this attitude which the American people tolerate. Is it not an indication of the decadent attitude that prevails?

The quality of our products suffers from an attitude of "get by with what you can," "do the least for the most money." This attitude leads not only to inferior products, but also to higher prices and, hence, inflation. Management is also a party to this situation, they permit a rise in the break-even point.

The conditions are attributable to the attitudes and actions of all our people, not to one group such as labor or management; we are all contributing in some way to the decline. We do not seem to be willing to view the situation with alarm. We are enjoying our luxuries, and in such enjoyment we are being selfish insofar as the future is concerned.

The young people of today are coming to believe that mediocrity in performance is natural, that perfection is something only fools strive for. Where do the younger people get these ideas? They come from the older people, those who are running the show.

There is already evidence that the United States is pricing itself out of the market place. Any product that depends largely upon labor in its manufacture is becoming more expensive largely because we are unwilling to give the best effort in as efficient and effective a manner as is possible.

Management may have contributed to this attitude on the part of its employees. Does management recognize its employees for a job well done? Do they encourage the high performance that will lead to better efficiency? In many instances they do not. We recognize that there may be interference to such recognition by rules established by union organizations, but there are ways in which management might make the partnership a little more appetizing.

The attitude of the American people has been described by John A. Patton, head of a Chicago management engineering firm, in the *Chicago Daily News* of August 22, 1958, when he said, "After watching the Germans, it is my opinion that American people have become allergic to hard work. The average American has no desire to do a good job. He is just putting in time for a wage."

The American people must be made to see this condition in its true light. They must be shown that to continue this soft condition will lead to a permanent loss of the position which the United States now enjoys.

A realization of the situation may be brought about through education, but this may not be to any avail since the educators may have fallen into the same soft state.

Lawrence A. Appley, president of the American Management Association, in an address before the Industrial Relations Section of California Institute of Technology, said that to cope with the fact that we are a high-cost, low-quality nation, "Management must rebuild worker pride, competency, respect and productivity."

Management would do well to heed Lawrence Appley's admonition. Action on their part could help to get the American people out of this critical situation. So also must labor do something about the state we are in.

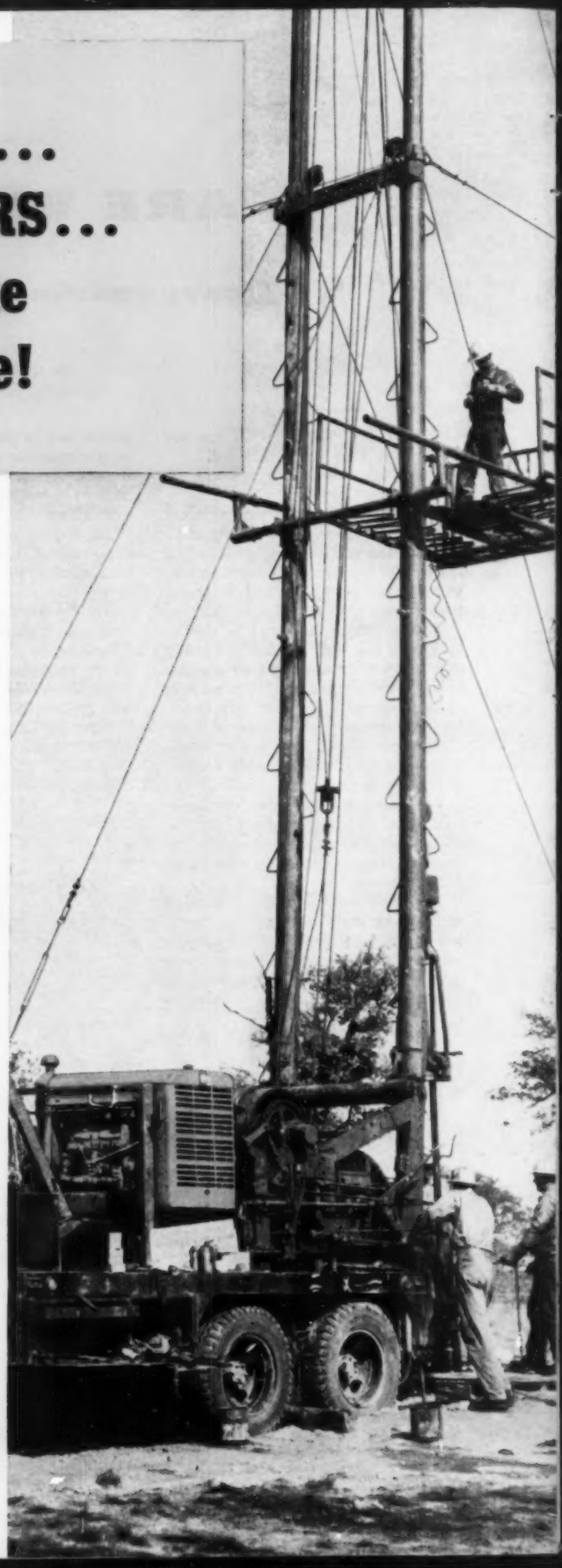
Organized labor has a big stake in this problem along with the stockholders of the corporations.

The group as a whole must take a strong stand against mediocrity.

Only when this stand is taken is there hope for the continual advancement of the United States and its prosperity and the attendant benefits to more of its people. ★ ★ ★

EDITOR'S NOTE: First published in Los Angeles Examiner and reprinted in "Seventy-Six", magazine of Union Oil Company of California. Dr. Clark, the author, is professor of mechanical engineering and director of placements, California Institute of Technology.

FOUR YEARS OLD... OVER 10,000 HOURS... International engine hasn't lost a minute!



James Bomar, driller for Pool Well Service, Kilgore, Texas, is another enthusiastic International power booster. On the job shown here, Driller Bomar and his crew punched a 3,500-ft. well in five days—with steady, reliable power from their International U-450 engine, on his Wilson drilling rig. "It's a dependable engine," says Mr. Bomar. "Year after year the same smooth power that can instantly wind up to top speed and get the pipe out of the hole in a hurry. We haven't lost a minute from this International in four years!"

You, too, can profit by using smooth, dependable International power for your oil field jobs. To adapt the engine to your specific needs there are fuel attachments for natural gas, combination natural gas and gasoline, and LPG; exhaust condenser; top cylinder oiler; automatic safety shut-off; automatic radiator shutter; horizontal magneto and gear driven mechanical governor.

Whatever your oil field power requirements—pumping, drilling, servicing, compressors or special applications—check the 32 models in the International engine line before you buy. Your nearby International Engine Distributor or Dealer can give you complete product information and installation assistance if needed. He stocks a complete line of 32 International diesel and carbureted engines ranging from 16.8 to 385 max. hp. All International engines have one common feature—fastest payback power for users.

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Management Personals

Maynard I. Landa was elected a vice president of Cities Service Petroleum, Inc. Since 1953 he has been petroleum economics coordinator for the Cities Service system. Landa joined the Cities Service organization as a junior engineer in 1919. He has served in various executive capacities in the field and in the New York headquarters office.

M. I. Landa

G. A. Peck

George A. Peck was appointed president of Southwestern Industrial Electronics Company, one of the Dresser Industries. He comes to S.I.E. from the Stromberg-Carlson Company where he served as vice president and general manager of the electronics division.

J. C. Martin Jr., formerly oil consultant in Slidell, La., was elected vice president and a director of United Cuban Oil Inc. His headquarters are at the home offices in Houston, Tex.

Wesley A. Songer, president of Crane Co., announced that the company has been formed into 5 groups, each with its own manufacturing, engineering, sales and control divisions. **Charles H. Lovelace** will head the industrial group; **W. D. LaRue,** the marketing department; **J. P. Magos,** engineering; **Walter Kovalick,** manufacturing.

T. B. Focke heads another group — plumbing-heating-air conditioning — with **R. W. Lindsay,** director of marketing; **L. N. Hunter,** director of engineering and **L. L. Hotsenpiller,** manufacturing.

H. R. Riggs, is named general manager of the Crane Supply Co., the third group. The fourth division is systems and controls group. **P. L. Yates** was appointed managing director of the International group, the fifth.

E. G. Collado, treasurer of Standard Oil Company (New Jersey), and **J. R. White,** president of Imperial Oil Ltd. of Canada, an affiliated company have been designated candidates for election to the board of directors at Jersey Standard's annual meeting May 25.

Jack W. Roach was named vice president-personnel of Kerr-McGee Oil Industries, Inc. His responsibilities include the administration of the company's industrial relations department and employee benefits section.

Dr. D. R. Frey, general manager, was named supervisor of a new department, product development and quality control. Also assigned to the department are: **L. W. Okon,** manager of sales technical services; **F. C. Champlin,** chief chemist; and **H. L. Norlin,** laboratory supervisor.

George A. McCulley, longtime employee of Stekoll Petroleum Corporation, was named secretary, and **Ronald M. Hawkins** promoted to vice president and treasurer. New executives are **B. Frank Harrison,** vice president, finance, and **Herbert B. Pier,** controller.

Maston Nixon was elected chairman of the board, and **Frank P. Peterson** was elected president and a director of Southern Minerals and Southern Pipe Line Corporations. Nixon has managed the companies and, in stepping up as chairman from president, will continue as the chief executive officer of Southern Minerals Corporation and its pipe line subsidiary. Peterson moves up from executive vice president, a position he has held since 1957.

W. C. Cheek, H. W. King and **W. J. Van Vleck** were elected commercial

W. C. Cheek

H. W. King

W. J. Van Vleck

vice presidents of Worthington Corporation. Cheek is Midwest regional sales manager; King, Western regional sales manager; and Van Vleck, Eastern regional sales manager.

A. William Fraser was elected vice president and general sales manager.

A new Southern resale region, with **R. N. Franz** appointed as manager was established. Headquarters for the region will be in Atlanta and will cover the sales territories of Atlanta, New Orleans, Houston, Dallas and Tulsa. **F. J. Reardon** was appointed Central region resale manager, succeeding Franz.

A. C. Rubel, president of Union of California, retires April 26. He will continue active association with the company he joined 38 years ago by remaining as a director and member of the executive committee, and be available for special assignments.

The board of directors contemplates that **Reese H. Taylor** will continue as chairman of the board and also serve as president. Rubel, one of the outstanding figures of the petroleum industry, was awarded the famous Anthony Lucas medal in February by the AIME.

Jay T. Yates, formerly assistant public relations manager for the Southwest Region, Pan American Airway's public relations department, was appointed to the public relations staff of Union.

J. W. "Win" Miller, executive representative for Union in San Francisco, also has retired. He will have completed nearly a quarter of a century of service with the company.

Donald P. Krotz was elected corporate secretary of California Research Corporation. In his new assignment Krotz will continue his present business manager functions.

Irving E. Chapman was named assistant general manager of Tidewater Oil Company's 14-state eastern division. Chapman was formerly executive assistant to the president.

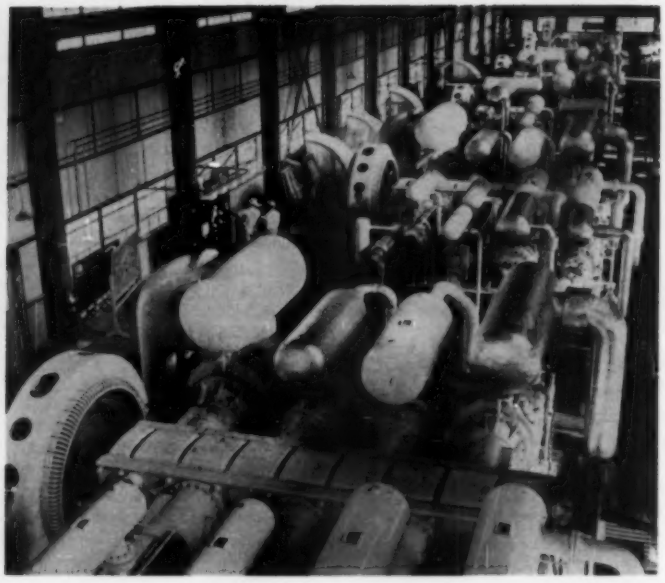
Robert L. Whiting, head of the department of petroleum engineering, Texas A&M College, was named acting director of the Texas Petroleum Research Committee, succeeding **Dr. George Fancher,** who resigned recently to become vice president for production research of Sinclair Research.

Roy B. Alcott was named employee relations manager of Tidewater Oil Company's 14-state eastern division. Alcott, formerly employee relations manager of the southern division, succeeds William O. Barnes, deceased.

L. L. Warriner was elected chairman of the board of The Cooper-Bessemer Corporation. **Grant C. Woodard,** general sales manager and **Harold C. Johnson,** manager of manufacturing, were elected vice presidents of the company.

Warriner was elected chairman upon the recommendation of **L. F. Williams** whom he succeeds. Williams, who is stepping down from the chairmanship after more than 40 years' service, will continue as a director and as a member of the executive committee.

A. J. Kelly, Esso Standard's general manager of purchasing, has retired ending a 41-year career in Esso purchasing operations.



Petroleum Chemicals, Inc., Installs 98 Burgess-Manning Snubbers To Prevent Pulsation Damage In New Ammonia Plant

Foster Wheeler Corporation was contracted by Petroleum Chemicals, Inc., to design and construct a multi-million dollar ammonia process plant at Lake Charles.

Realizing that gas pulsation would cause severe operating problems in the multi-service process piping related to reciprocating compressors, and that hazardous pulsation should be engineered out of the plant in the initial design, Foster Wheeler called upon Burgess-Manning Company to develop pulsation snubbers for various service conditions and for installation under the original contract.

Ninety-eight pulsation snubbers of 46 individual designs were installed on multi-stage, multi-service compressors. The snubbers were installed on both the suction and discharge sides of the compressor cylinders in what is believed to be *the largest single installation of pulsation snubbers under one roof.*

The compressors handle various types of gases, ranging in molecular weight from 5.13 to 33, at pressures from atmospheric to 9,270 P.S.I.A.; and at discharge temperatures to 350° F. Under these exacting conditions, Burgess-Manning accepted the responsibility to engineer and supply pulsation snubbers of optimum design that would: *1. Hold the pulse amplitude to 2 per cent or less, total surge peak-to-peak, of absolute line pressure, and 2. hold a minimum pressure drop requirement.*

The snubbers were subjected to the stringent specifications of material, workmanship, and inspection procedures normally followed by Foster Wheeler in process plants of this type. All forged snubbers for high-pressure service were made of high tensile alloy steel. Internal assemblies were engineered to withstand extreme forces.

After the plant went on stream, operational inspection revealed minimum pulsation-induced vibration, eliminating operating hazards, constant maintenance, and upkeep of the laterals, headers, intercoolers, and separators attendant to the snubbers.

If you are planning a new plant, or have a pulsation problem in your present plant, it will pay you to consult Burgess-Manning — "The Sound Engineering People." There's no obligation, of course.

Sound Engineering

INDUSTRIAL SILENCER DIVISION

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Sales Engineering Representatives Coast to Coast

▸ **F. C. Aldrich,** manager of the Ohio Oil Company's Sidney (Neb.) production district, was named manager of the company's newly established international oil sales department. Aldrich, who will be headquartered at London, England, will be responsible for the sale of Ohio Oil's crude oil and associated liquids other than in the United States and Canada.

F. C. Aldrich

Carstens Slack

▸ **Carstens Slack** was promoted to manager of Phillips Petroleum Company's Washington office, replacing the late E. D. McElvain. **James Fitchette** was appointed manager of the public relations division, advertising and public relations department succeeding Slack. An editorial division headed by **R. E. Jeffrey,** editorial director, has been created in the department.

Marvin L. Collins was named assistant to the manager of the tax, insurance, and claims department. He had been manager of the department's Houston division and is succeeded by **John W. Craddock.**

▸ **Paul L. Henderson** became vice president of international production and **Glenn F. Bish** vice president of domestic production in The Ohio Oil Company's production organization. Henderson will head all of Ohio Oil's exploration and production activities outside the U. S. and Bish will be in charge of exploration and production in the U. S.

▸ **Roy C. Ingersoll,** chairman of the board of Borg-Warner Corporation, was elected a senior board member of the National Industrial Conference Board for a 3-year term at the 401st meeting in February. Three Chicago business executives were re-elected board members for one year. They are: **John A. Barr,** chairman of the board of Montgomery Ward & Co., Inc.; **Champ Carry,** president of Pullman Inc., and the **Hon. James Scott Kemper,** chairman of Lumbermens Mutual Casualty Company.

▸ **Bertram J. Milleville,** formerly director of engineering and research, has been elected vice president of engineering and research at The Ohio Injector Company.

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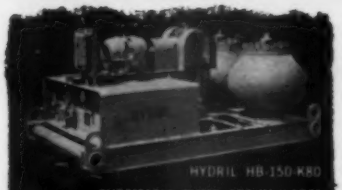
HYDRIL has the SAFE answers

TO DRILLERS' PRESSURE-CONTROL PROBLEMS!



HYDRIL HB-150-KBD
AUTOMATIC PUMP ACCUMULATOR

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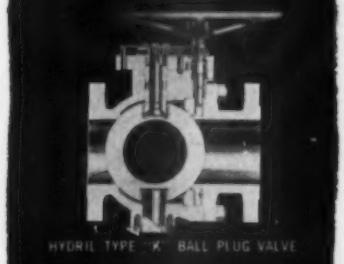
K-20
PULSATION
DAMPENER



HYDRIL TYPE "K" BALL PLUG VALVE

HYDRIL "GK" BLOWOUT PREVENTER

HYDRIL
TRIPLESEAL
CASING
JOINT

HYDRIL
"CS"
TUBING
JOINT

above-ground

No blowout prevention control program is better than the power available to operate it, and HYDRIL AUTOMATIC PUMP ACCUMULATORS made to match Hydril Blowout Preventers, assure safety in *any* control system by providing a constant, instantly available source of hydraulic power to actuate hydraulically operated blowout prevention equipment. Choice of engine or motor driven units, in a wide range of hydraulic storage capacities.

To take dangerous vibration out of rotary hose, HYDRIL PULSATION DAMPENER absorbs surge at the reciprocating mud pump . . . saves possible injuries to drilling crew . . . saves damage to costly equipment.

All drilling fluids—abrasive or not—are handled with equal ease by HYDRIL TYPE "K" NON-LUBRICATED BALL PLUG VALVES. New patented compressible port seal is the secret of seep-proof shutoff, continued easy operation. Hydril Ball Plug Valves always work on the first try . . . can't stick or freeze . . . require minimum maintenance to stay in perfect working order.

in-the-cellar

HYDRIL BLOWOUT PREVENTERS successfully contain dangerous downhole pressures while permitting various sized members of the drill string to pass in and out of the hole . . . will actually pack off the open hole in complete safety!

Type "GK" for high-pressure wells, "MSP-2000" for low and medium pressures, "GK-6-10000" for highest pressures.

downhole

You're steps ahead with Hydril's two-step thread. HYDRIL CASING JOINTS make up and break out faster because you make up two threads at once. They save running time . . . hold greater pressures because they seal at *three* places.

The same holds true for HYDRIL TUBING JOINTS. Pressure-tight when made up, you can depend on them to stay that way. There's a wide range of Hydril Joints for faster, safer drilling and completion operations.

HYDRIL INSIDE BLOWOUT PREVENTERS . . . Well Guard; Drill Pipe, Tubing and Casing Plugs; Drill Pipe Float Valves and Back-Pressure Valves . . . effectively block downhole pressures inside the pipe while the Hydril Blowout Preventer is effectively sealing off the annulus.

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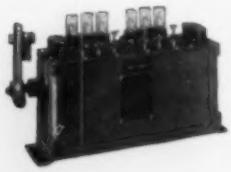

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UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

▸ **A. E. Oldham,** independent geologist of Dallas was elected a member of the board of Aztec Oil & Gas Company. **Quilman B. Davis,** formerly secretary and general attorney, has been promoted to vice president and general attorney. **Arland L. Ward,** treasurer, has been promoted to secretary and treasurer.

▸ **William K. Whiteford,** president of Gulf Oil Corporation, was elected a member of the advisory committee of The International Nickel Company of Canada, Ltd.

▸ **John Kelly** was promoted to assistant general manager of Continental Oil Company's southwestern region, with headquarters in Fort Worth. Formerly vice president of Continental Pipe Line Company, a wholly owned subsidiary of Conoco, he succeeds **Roy M. Mays,** who recently transferred to Houston as director of reserves and production acquisitions.

▸ **C. W. Ledebur,** associated with Forest Oil Corporation for 30 years, has been appointed vice president in charge of exploration. Ledebur joined the Forest organization at their home office in Bradford, Pennsylvania and was transferred to Texas in 1936.

▸ **James L. Rumsey** has joined Delhi-Taylor Oil Corporation in Dallas, Texas, as administrative assistant in the executive division. He will report to **C. H. Hobbs,** corporate secretary and executive assistant to the president.

Prior to joining Delhi, Rumsey was associate analyst in the coordinating and planning department of Continental Oil Company in Houston.

▸ **Dr. R. W. Brauchli,** Oklahoma City, has been made vice president of exploration and production for Anderson-Prichard Oil Corporation. Dr. Brauchli was appointed vice president of the exploration department in 1947 and upon the consolidation, following the recent retirement of **Weston "Buck" Payne,** he assumes directorship of the production division.

▸ **Webb B. Cooley** was named manager of Mobil Oil Company's Southwest ad valorem tax area. He will be responsible for property tax work in connection with Mobil's producing, marketing and manufacturing operations, as well as Magnolia Pipe Line Company operations, in a total of 15 states. Previously ad valorem tax manager for Magnolia Petroleum Company, Cooley will continue to headquarter in Dallas. He will report to **C. B. Wallace,** associate general counsel.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

▸ **W. D. Seyfried** was appointed to the newly created position of manager of research for Humble. He has been serving as head of the Baytown refinery's research and development division, will be responsible for coordination of all scientific research carried out by Humble. He will also be responsible for advising the company's board in regard to available research programs, for formulating and recommending research policies and plans, and for evaluating research results in the light of the company's needs and objectives.

▸ **Dr. Robert Price Russell** and **James Jackson Minot** were elected directors of Cosden Petroleum Corporation, subsidiary of W. R. Grace & Co. Cosden's board also includes **Raymond L. Tollett,** president and general manager, **Marvin M. Miller,** senior vice president, producing division; **Nelson Phillips Jr.,** vice president, secretary and general counsel; **Wm. H. Hawn, Wm. H. Hayes, Lowell E. Ullery** and **Thomas I. Sheridan, Jr.**

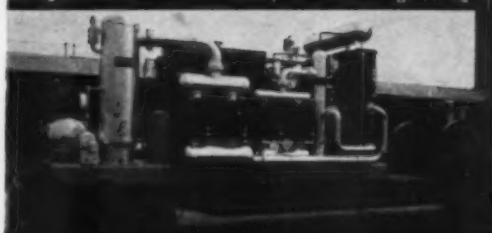
▸ **Henry J. Wallace,** former vice president in charge of sales, National Tube Division of U. S. Steel, was appointed president to succeed **John E. Goble,** who retired. **William F. McConnor,** executive vice president of the tube division since 1950, also retired and was succeeded by **Edmund G. Price,** former vice president of operations. **Truman H. Kennedy** will take over Price's former post, and **Robert E. Williams** becomes vice president of sales.

▸ **Burtram McClain** was elected vice president and general manager of Aero Service Corporation. He joined the international air survey firm as secretary-treasurer in 1945. **Charles B. Ermentrout** succeeds McClain as treasurer, having been assistant treasurer. **Eugene C. Cook** became secretary, formerly assistant secretary. **Harry G. Franke** was advanced to controller from production manager.

▸ **David James** was named a sales engineer with the Dallas offices of The Cooper-Bessemer Corporation. He was previously assigned to the Cooper-Bessemer Mount Vernon office in a sales engineering capacity.

▸ **Dr. H. Dayton Wilde** was appointed to the newly created position of university relations counselor for Humble Oil & Refining Company. Dr. Wilde will be responsible for fostering good relations with the colleges and universities from which Humble recruits many of its new employees. He will carry on a continuing study of the fellowship and scholarship programs and other aids to education supported by Humble.

Natural Gas Field station with three 550 hp packaged compressors cooled by Young.



Skid-mounted 440 hp compressor, cooled by Young jacket water cooler, being transported on a truck.

Young "JWC" UNITS COOL POPULAR NEW "ALL-IN-ONE" PACKAGED COMPRESSORS

Prefabricated compressors must be ruggedly built to withstand moving from field to field as needs dictate. Young-built Jacket Water Coolers are engineered to "take it" in the field and on the road . . . are built to last the lifetime of the plant. Heavy formed steel channel side members, steel side supports for cores, press-formed heavy-gauge non-ferrous specially reinforced headers are a few of the outstanding Young features that combine to form a rigid unit capable of withstanding severe vibration and shock. New developments of core structure and arrangements of component parts provide greater low-cost cooling.

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Engine or Compressor Lube Oil
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YOUNG RADIATOR COMPANY

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Plants at: Racine, Wisconsin and Mattoon, Illinois

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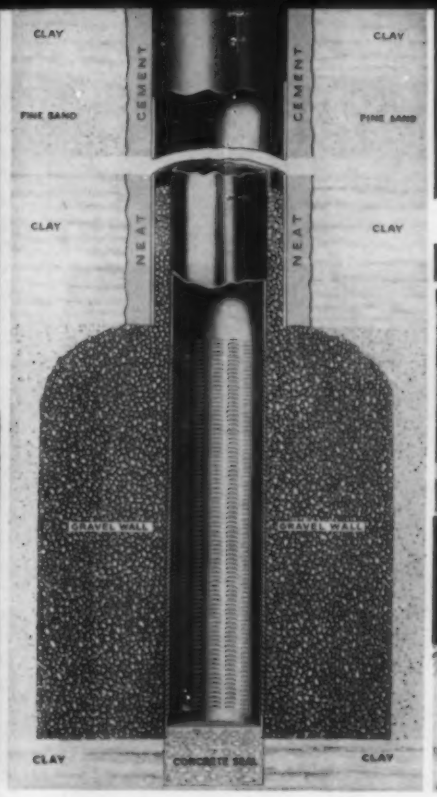
"It is important to note that the unfolding possibilities of science and technology are likely to be realized at an even greater pace in the future. For discovery and invention feed on themselves. With every new discovery and invention we broaden the base upon which others are built."

— M. J. Rathbone, President

Standard Oil Company (New Jersey)



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With A Layne Gravel Wall Well This technique and resulting arrangement of the new 134 Shutter Screen and gravel (shown here) permits the free flow of water into the well and affords the following advantages: larger shutter screen openings, reduced friction, reduced draw down and pumping head—thereby reducing pumping costs, increased specific capacity and more effective retention of native sands. Cemented wells are installed if indicated, and result in greater purity of supply as well as increased life of the well. *Bulletin No. 900*

With A Layne Vertical Turbine Pump Whatever the pumping requirement, there's a Layne pump to meet any pumping conditions. Layne Vertical Turbine Pumps come in a wide range of sizes and capacities, delivering 30 to 20,000 GPM and requiring from 4 to 42 inch well casings. The complete line of Layne Pumps include: Deep Well Vertical Turbine (oil or water lubricated), Short Coupled Vertical Turbine, Propeller, Mixed Flow, Fire Pumps and Volatile Liquids Pumps, Regular and "In-Line" Submersible. *Bulletins No. 200 (oil) 201 (water)*

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PHILADELPHIA 6, PA. SINCE 1872

Expansion Program. A. D. Rose, president of Marsh Instrument Company division of Colorado Oil and Gas Corporation has announced plans for a large expansion program. Contracts for factory enlargement have been awarded and orders for additional machinery and equipment have been issued or will be in the near future. Upon completion of the program, an increase of 40 percent of production capacity will have been added to the existing facilities, he stated.

Grove Opens Southwest Plant. Grove Valve and Regulator Company is now producing one of its major products, the G-4 gate valve, at a newly-converted plant in Longview, Texas.

Prompted by increased product demand in the Southwest and a desire to improve customer service, production at Longview will be limited to the G-4 valve and Valv-Pak products. Marvin Grove, president, added, however, that "it is conceivable that other Grove valves may have to be added to the Longview production schedule — provided demands continue to increase," but he emphasized that there were no immediate plans to further expand the Longview operation at this time.

Erecting Truck Parts Depot. Construction is scheduled to start immediately on a new International Harvester Company motor truck parts depot in Fort Wayne, Indiana. Planned as the company's largest parts distribution facility, the building will have a total area of 625,000 sq ft, or about 15 acres under roof, and will feature modern material handling equipment including 2846 lineal ft of tow line floor conveyor with 10 automatic switching stations and 335 electronically equipped station selector dolly trucks.

Engine Plant. Construction of a multi-million dollar engine manufacturing plant at the Harvey (Ill.) Works of Allis-Chalmers Manufacturing Company was announced. It will be 1100 ft long and 440 ft wide and will occupy part of 35 acres of land. It will be a one story, steel beam and cement construction plant with about 515,000 sq ft of floor area.

▸ **C. L. Fleming,** 79, retired director and vice president of refining and marketing operations of the Ohio Oil Company, died February 8 following a recent heart attack.

▸ **Col. Thomas K. McElroy,** 54, Ohio Oil Company attorney headquartered at Houston, Texas, died unexpectedly March 2, following a heart attack. He was a former professor at Baylor University law school and the author of several legal textbooks.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

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Both rigs dual trailer mounted.
One GMC 2-ton truck. — One International 6 x 6 3-ton truck.
Both trucks equipped with oil field beds and fifth wheels for moving rigs; dual trailer floats and winches; gin poles. Two dog houses, three light plants, one 1959 Chevrolet ½-ton pickup and other miscellaneous accessories.

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CONDENSATE? or DISTILLATE?

THE FLAGRANT MIS-USE of the words **distillate** and **condensate** within and outside our industry has caused many an oilman a very serious headache!

Although differences between the two words are technically precise and distinctive, many persons in or closely associated with the oil and gas industry continue to create confusion about these products. Recently a headline was noted on the oil page of a leading oil reporting Texas newspaper — "Joe Doaks completes excellent Gas-Distillate well in West Texas."

Let us closely examine a few authoritative definitions of the words causing the trouble:

Condensate

The liquid produced by the condensation of a vapor or gas.

Condensate shall mean the liquid recovered at the surface that results from condensation due to reduced pressure or temperature of petroleum hydrocarbons existing in a gaseous phase in the reservoir.

A hydrocarbon which is gaseous in the ground, but when produced condenses into fluid.

Distillate

A product of distillation or the fluid condensed from the vapor driven off in the still. Gasoline, naphtha, kerosine, and light lubrication oils are examples of distillates, since they are the result of distillation of crude oil.

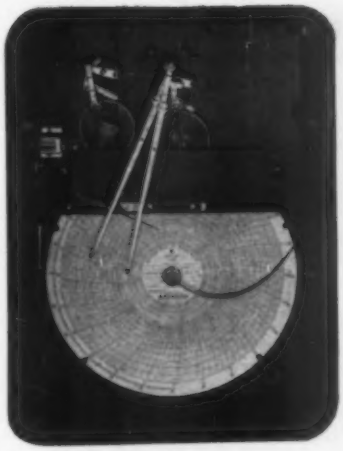
A product which has been distilled from petroleum.

Distillation

A process which utilizes heat to vaporize one liquid from another such as separating gasoline from crude oil.

If we are willing to accept the existing authoritative definitions of these two English words, the technical truth of the matter is that THERE IS NOT A SINGLE DISTILLATE PRODUCING WELL ON THE PLANET EARTH!

(By Glen D. Brown in *THE LANDMAN, June, 1959.*)



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Meetings . . .

Apr. 5 — **Petroleum Equipment Suppliers Assn.**, southern Mid-Continent district, Statler Hilton Hotel, Dallas, Tex.

Apr. 5-6 — **Gas Compressor Institute**, annual, National Guard Armory, Liberal, Kans.

Apr. 7-8 — **Rocky Mountain Oil & Gas Assn.**, midyear meeting, Newhouse Hotel, Salt Lake City, Utah.

Apr. 12-14 — **Petroleum Industry Electrical Assn. and Petroleum Electric Supply Assn.**, conference and exhibit, Muehlebach Hotel, Kansas City, Mo.

Apr. 13-15 — **Kansas Oil Men's Assn.**, Management Institute, University of Kansas, Lawrence.

Apr. 18-19 — **Conference on Automatic Techniques**, sponsored by National Conference Committee (ASME, IRE, AIEE), Cleveland-Sheraton Hotel, Cleveland, O.

Apr. 19-21 — **Southwestern Gas Measurement Short Course**, North Campus, University of Oklahoma, Norman, Okla.

Apr. 20-21 — **National Petroleum Assn.**, semi-annual meeting, Sheraton-Cleveland Hotel, Cleveland, Ohio.

Apr. 20-22 — **API Division of Production**, Rocky Mountain district meeting, Gladstone, Henning, and Townsend hotels, Casper, Wyo.

Apr. 21-22 — **West Texas Oil Lifting Short Course**, Texas Technological College, Lubbock, Tex.

Apr. 24-26 — **Independent Petroleum Assn. of America**, midyear meeting, Denver Hilton Hotel, Denver, Colo.

Apr. 25-27 — **Southern Gas Assn.**, convention, Buccaneer and Galvez hotels, Galveston, Tex.

Apr. 25-28 — **American Assn. of Petroleum Geologists-Society of Economic Paleontologists and Mineralogists**, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Apr. 25-29 — **American Welding Society**, annual meeting and welding exposition, Hotel Biltmore, Los Angeles, Calif.

Apr. 27-29 — **Natural Gasoline Assn. of America**, annual convention, Rice Hotel, Houston, Tex.

Apr. 28-29 — **API Division of Transportation**, pipeline meeting, Mayo Hotel, Tulsa, Okla.

Apr. 29 — **API Board of Directors**, meeting, Sheraton East Hotel, New York City.

May 1-4 — **The Asphalt Institute, Division I**, meeting of management committee, Homestead, Va.

May 1-4 — **4 LPGA**, annual convention and trade show, Conrad Hilton Hotel, Chicago, Ill.

May 2-3 — **Society of Petroleum Engineers of AIME**, biennial North Texas secondary recovery symposium, Wichita Falls, Tex.

May 2-6 — **API Safety and Fire Protection Committees**, midyear meeting, Atlanta-Biltmore Hotel, Atlanta, Ga.

May 5-6 — **AIME**, Rocky Mountain petroleum sections, annual joint meeting, Calgary, Alta.

May 5-6 — **Canadian Institute of Mining & Metallurgy**, annual technical meeting of petroleum and natural gas division, Palliser Hotel, Calgary, Alta.

May 9-12 — **API Division of Refining**, midyear meeting, Statler and Sheraton-Cadillac hotels, Detroit, Mich.

May 11 — **The Asphalt Institute, Division VI**, management committee meeting, Tulsa, Okla.

May 11-12 — **Gas Conditioning Institute**, University of Kansas, Southwest Kansas Center, Liberal, Kansas.

May 12-13 — **API Division of Production**, Pacific Coast district meeting, Biltmore Hotel, Los Angeles, Calif.

May 12-14 — **Kansas Independent Oil & Gas Assn.**, annual meeting, Lassen Hotel, Wichita, Kans.

May 16-17 — **International Society of Professional Well Log Analysts**, annual meeting, Tulsa Hotel, Tulsa, Okla.

May 23-26 — **American Society of Mechanical Engineers**, Oil and Gas Power Division Conference, Hotel Muehlebach, Kansas City, Mo.

May 23-24 — **American Gas Assn.**, production meeting, Roosevelt Hotel, New York, N.Y.

May 25-28 — **American Assn. of Petroleum Geologists**, Western Canada regional meeting, Banff Springs Hotel, Banff, Alta.

May 26-27 — **Rocky Mountain Oil & Gas Assn.**, annual refining meeting, Newhouse Hotel, Salt Lake City, Utah.

June 1-3 — **Appalachian Underground Corrosion Short Course**, West Virginia University, Morgantown.

June 1-3 — **Short Course in Gas Technology**, Texas College of Arts and Industries, Kingsville, Tex.

June 2 — **Pennsylvania Grade Crude Oil Assn.**, annual meeting, Pennhills Club, Bradford, Pa.

June 2-3 — **Kentucky Oil & Gas Assn.**, annual meeting, Phoenix Hotel, Lexington, Kentucky.

June 8-11 — **National Society of Professional Engineers**, annual meeting, Statler Hotel, Boston, Mass.

June 9-11 — **Interstate Oil Compact Commission**, midyear meeting, Sheraton-Cadillac Hotel, Detroit, Mich.

June 12-17 — **API Division of Production**, midyear committee conference, Sheraton-Dallas Hotel, Dallas, Tex.

June 22-25 — **American Assn. of Petroleum Landmen**, annual national convention, Ambassador Hotel, Los Angeles, Calif.

June 26-28 — **North American Gasoline Tax Conference**, annual meeting, southern region, Eden Roc Hotel, Miami Beach, Fla.

June 25-29 — **Petroleum Equipment Suppliers Assn.**, silver anniversary meeting, Banff Springs Hotel, Banff, Alta.

GALVANIZE with Z.R.C.® to stop RUST!

Offshore drilling operators forget corrosion problems for four to five years when rigs are coated with Z.R.C.

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Laugh with Barney

Some women say that men are so broad minded they can't think of anything else.

Say, Pete, you drink quite a bit. Tell me, does your tongue burn after you've had a few drinks?

I don't know, Joe, I've never been drunk enough to try and light it.

A man in Alaska was arrested for bigamy. He had a wife in Nome, another wife in Fairbanks, and still another in Juneau. The judge looked down at the culprit and sternly remarked, "How could you do such a thing?" To which the bigamist replied, "Fast dog team."

A saint has been defined as a person who's good when nobody is looking.

"How old did you say you were?" asked the doctor of his female patient.

"I never mention my age," replied the patient, "but as a matter of fact, I've just reached twenty-one."

"Indeed?" said the doctor. "What detained you?"

A wolf is like a modern fluid cleaner — he works fast and leaves no ring behind.

Young Son: Dad, mom just backed the car out of the garage and ran over my bicycle.

Dad: Serves you right for leaving it on the front lawn.

An Indian, the tribe's smoke-signal expert, stood on a New Mexico butte, overlooking the atomic testing grounds. In the distance an atomic blast was discharged. The Indian watched in awe and wonder as the typical mushrooming column of smoke and fire rose majestically a thousand, five thousand, and then ten thousand feet into the desert air. The Indian gazed in admiration, then lowered his eyes and slowly shook his head.

"I wish I'd said that," he murmured.

A man walked into a bar, sat on a stool and said to the bartender, "Give me something tall, cold and full of gin."

Whereupon the man sitting on the next stool drew himself up straight and said, "Sir, I'll have you know you are speaking of the woman I married."

The petroleum engineering section reports that girls with the most streamlined shapes usually offer the most resistance.

The drunk sitting at the bar was adjacent to a man and his wife. Suddenly the drunk came forth with a resounding burp.

"How dare you belch before my wife," thundered the husband.

With that the drunk unsteadily got off the bar stool and, making a sweeping bow, said, "A thousand pardons, sir . . . I did not know it was the madam's turn."

Many people don't like to repeat gossip, but what else can you do with it?

Send your stories to:
Barney, Box 1589, Dallas 21, Texas

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Books To Read . . .

Management's Right to Manage *by George W. Torrence; 109 pages; published by The Bureau of National Affairs, Inc., 1231 24th Street, N. W., Washington, D. C.; $12.50.*

"You aren't often asked to give up a right in toto. More likely you are confronted with a demand to give up just a *little piece* of that right. For example, you are not asked to give up your right to introduce new methods — instead, you are asked that no jobs be changed, or new jobs established, without mutual agreement."

"You are not asked to give up your right to expect from each employee a good day's work — instead, you are asked not to change any production standards except by mutual agreement."

These are some of the methods of eroding management's rights.

Mr. Torrence has gone thoroughly into a confusing and intangible problem. Management has lost rights through arbitration and court decisions but the author states firmly: "Practically all of the rights which really have been taken away from management are those which management itself has given away . . ." "By far the vast majority of limitations on the rights of management have been surrendered by management knowingly, in many cases voluntarily, and in other cases unvoluntarily, and in other cases under varying degrees of pressure, ranging from the mild force of argument to the mighty force of the knock-down, dragout strike . . ."

Industrial Leadership—The American Way to Teamwork, *by Clarence A. Weber and John W. Karnes, Jr. Published by Chilton Company, 56th and Chestnuts Streets, Philadelphia 39, Pennsylvania. Pages, 226. Price, $5.*

"One of the most pressing problems facing industry and business all over the free world is of 'upgrading' men and women to assume positions of leadership. 'Upgrading' is another name for in-service training or in-service education." This paragraph is the key to an excellent book on American management.

In a nation committed to a free economy and democratic political control, leadership must come from the constant exchange of ideas between the educator and the industrialist, these authors believe. They conclude that management must be greatly concerned with upgrading employees to assume positions of leadership so that a perpetuation of the life we cherish may be guaranteed. Questions are provided at the end of each chapter for the use of groups studying the problems of leadership.

An Introduction to the Organic Chemistry of High Polymers, *by Carl S. Marvel. Published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, New York. Pages, 298.*

This book, derived from the Humble Lectures in Science presented by Marvel in June 1956, is adapted to the interests of those just starting research in polymer chemistry. The author gives a short history of polymer chemistry and touches briefly on methods used to characterize polymers before going into a point-by-point study of polymer formation and reactions. He defines terms used before developing each topic, thereby leaving no doubt in the reader's mind as to exactly what is meant in references to such basic concepts as polymerization, linear polymers, condensation and addition polymerization, branched and cross-linked polymers, etc.

The author, a research professor of organic chemistry at the University of Illinois, is a member of the advisory boards for Wiley's *Organic Syntheses* series and the *Journal of Polymer Science*.

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- ☐ 722 Bethlehem Yellow
- ☐ 726 New Emsco Green
- ☐ 727 New Unit Rig Gray
- ☐ 724 Waukesha Gray
- ☐ 721 National Blue
- ☐ 723 Oil Well Orange

▸ **The Sea Off Southern California, a Modern Habitat of Petroleum,** *by K. O. Emery. Published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, New York. Pages, 366. Price, $12.50.*

If you are interested in the search for or development of petroleum off the southern coast of California, you will want to read this book, the first full-scale treatment of the Southern California underwater area. All aspects of geology are treated and synthesized in this discussion. Featuring a close tie between text and illustrations, the book contains answers to questions of interest to oil geologists and oil companies, such as the distribution of rocks of various ages offshore, the locations of oil seeps, and the heights of waves. Of more fundamental interest is the inclusion of new data on the origin of oil: the dependence of hydrocarbons on environmental factors such as production of phytoplankton, oxidation, and dilution by detrital sediment.

▸ **Hugoton Embayment—Anadarko Basin Handbook,** *compiled and edited by Curtis and Don Stevens. Published by National Petroleum Bibliography, P. O. Box 3586, Amarillo, Texas. Pages, 412. Price, $25.*

Covering activity to the end of 1959, this handbook will bring you up to date on the past events in the five-state Panhandle area of Texas, western Oklahoma, southwest Kansas, southeast Colorado, and northeast New Mexico. Contents include: discovery, geological, reservoir, and field information on more than 600 oil and gas fields in the Amarillo-Hugoton area; nearly 150 geologic structure maps, isopachs, and cross sections; a bibliography of books, articles, papers, maps, and cross sections compiled on the region; detailed classification of sources for operation information; directory of operators actually drilling wells in the area; directory of consulting geologists and engineers headquartered in the area; and a summary of activity in the 60,000-sq mile province.

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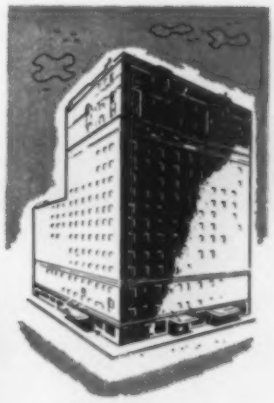
The Beautiful Lamar



Houston's Hotel of Distinction

You'll like the extra luxuries and comforts which distinguish The Lamar... It's completely air-conditioned of course, with TV and radio in guest rooms. And food to please the most discriminating. Rates begin at $4.50. Garage Service.

GEORGE B. ADAMS
General Manager

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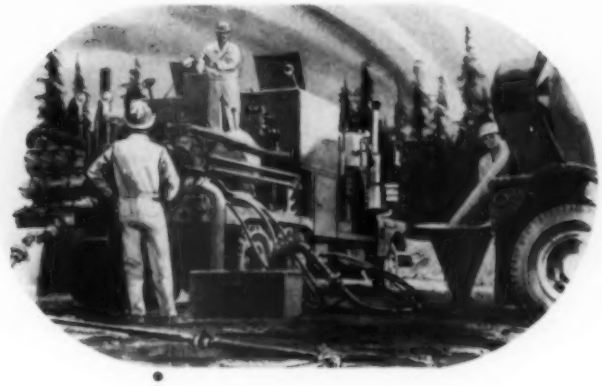
TWO NEW HALLIBURTON FLOAT VALVES

DESIGNED for CEMENTING ECONOMY



SAVE ON INITIAL COST

SAVE TIME IN RUNNING CASING

SAVE EXCESSIVE DERRICK STRAIN

SAVE ON DRILL-OUT TIME

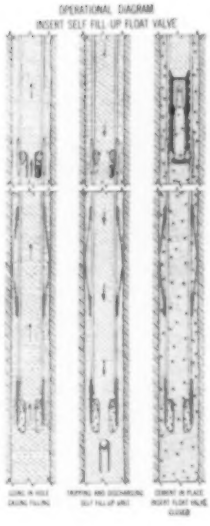
INSERT FLOAT VALVE

This new Halliburton tool is low in cost, simple in design, and efficient in operation. Installed by a short thread inside the casing coupling and sealed between the casing ends, no length is added to the string. Eliminates two threaded connections for each valve used in the string.

Designed for use in wells where a medium range of differential pressures exist, the assembly consists of a readily-drillable cast aluminum body, flapper valve and spring and two rubber sealing rings. The stout spring helps hold the valve closed during floating-in and after cementing is completed. This tool is excellent for use with a "DV" Multiple Stage Cementer.

INSERT SELF FILL-UP FLOAT VALVE

A combination of the new Insert Float Valve described above and a simple self fill-up assembly incorporating a plastic orifice tube, the Insert Self Fill-Up Valve was designed for use in filling casing in areas where field conditions sometimes interferred with other fill-up devices. See illustration. A pre-selected, special size orifice tube holds the valve open allowing the casing to fill going in the hole. When the casing is within a few joints off bottom, a weighted plastic ball (furnished) is dropped and seats on the valve. After reaching casing point, pressure is increased to break the orifice out of its seat. The plastic flow tube and ball drop through the guide nose to the bottom. The valve then closes and acts to help prevent reverse circulation during and after the cementing operation.



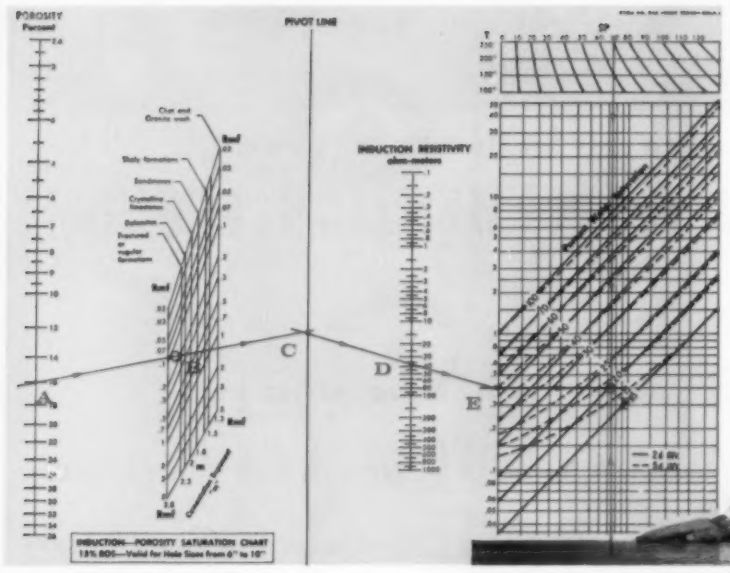
ASK your local Halliburton Representative about these new valves. He will help you select the proper unit to match your well's requirements.

HALLIBURTON

CEMENTING SERVICES

HALLIBURTON OIL WELL CEMENTING COMPANY • DUNCAN, OKLAHOMA

"TOOLS AND EQUIPMENT TO MATCH THE JOB"



'Most Anybody Can Read A WELEX Log!

Logging expert or not, just about anyone can read a Welex log—and within minutes come up with the answer to the all-important question. WILL THE WELL PRODUCE?

Based on only four logging services, Welex's new simplified logging program requires only two decisions.

1. Which log—Radiation or FoRxo—will give the proper POROSITY reading? This choice is based on whether the porosity in the formation is intergranular or fractured or vugular.

2. Which log—Induction or Guard—will give the proper value to determine FLUID SATURATION? This choice is based on the salinity contrast between drilling mud and formation water.

The diagram at lower right shows how simple these choices are, regardless of bore hole characteristics.

Once the right logs are run, the POROSITY in the zone of interest can be read directly off the Porosity Scale on either the Radiation or FoRxo log.

Calculation of the FLUID SATURATION is equally simple with the easy-to-use Interpretation Charts or "pigtails" printed conveniently at the end of either the Induction or Guard Log.

The "pigtail" chart above, taken from an Induction Log, illustrates the steps necessary to calculate FLUID SATURATION. In this example, Radiation-Induction Logs gave the following values: porosity (read directly off the Neutron Porosity Scale)—16 percent; Induction resistivity value—32 Ohms; SP value—70 millivolts.

A. Pinpoint the porosity value on the Porosity Percent Scale.

B. Pinpoint the intersection of the Rmf value of .2 Ohms (taken from the log heading) with the formation-type line in the Formation Grid Chart. (Type of formation will be known by the engineer or geologist on the well.)

C. Connect points "A" and "B" with a straight line and extend it to intersect the Pivot Line at point "C".

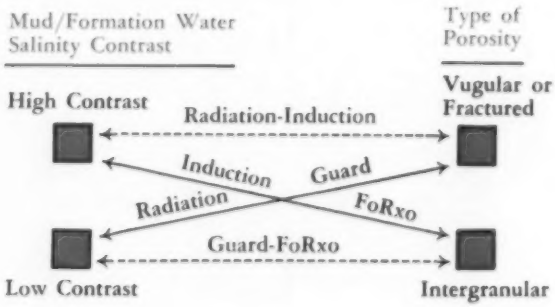
D. Pinpoint the Induction value on the Induction Resistivity Scale and connect it to point "C" with a straight line extended to intersect the Water Saturation Chart at point "E". Draw a horizontal line from point "E" across the chart.

E. Pinpoint the Rmf/Rw value (if known from Rw data in the area) on the Rmf/Rw Scale at the bottom of the chart and raise a vertical line to intersect the horizontal line at point "F". (If the Rw data is not available, an alternate method is to pinpoint the SP value (70 millivolts) on the SP Scale at the top and drop a vertical line.

F. Read the percent of FLUID SATURATION at the intersection of the two lines. The answer in this illustration is 19 percent.

Simple, accurate, easy.

Have your nearest Welex representative give you full information about the new logging program and easy-to-use "pigtail" charts. He can solve your logging problems.



WELEX, INC.

ORIGINATORS OF JET PERFORATING

General Offices: 1400 East Berry, Fort Worth, Texas
In Canada: Welex of Canada, Ltd.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Of Things To Come . . . In Oil

BUREAU OF MINES HELIUM OPERATIONS are expected to show a gross income of $10.1 million during the next fiscal year, and expenses of $7.6 million will leave a net operating income of $2.5 million. Three new gas wells will be drilled and equipped in the government-owned Cliffside gas field, feeding gas to the Amarillo helium plant. According to Bureau officials, about ten times as much helium is now wasted as is recovered in present plants and used, so legislation permitting construction of more processing plants is being requested.

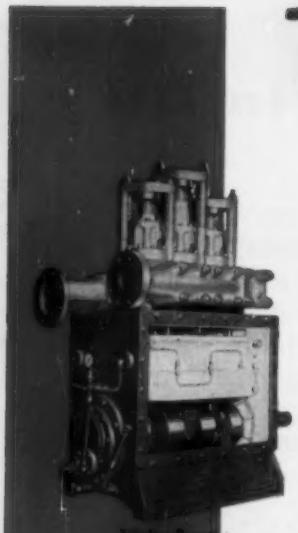
INCREASED USE OF ELECTRONIC DATA PROCESSING by the industry will result from IBM's new $2.5 million computing center in Poughkeepsie, N. Y. Facilities are available to corporations on an hourly rental basis. Shell Oil Company was the first customer in line to use the facilities, using the equipment to calculate the economics of petroleum distillation methods.

RUSSIA WILL REPLACE U. S. AS LEADING PRODUCER if Soviet plans are realized. *Petroleum Today,* an API publication, declared that a rich new oil basin in Russia, promising new drilling techniques, and lavish state support make the Soviet Union "a genuine threat" to U. S. leadership in oil production. However, the magazine said that the U. S. is expected to require a daily production of 14 million barrels in 1975, or twice the rate the Soviets hope to reach in 1972.

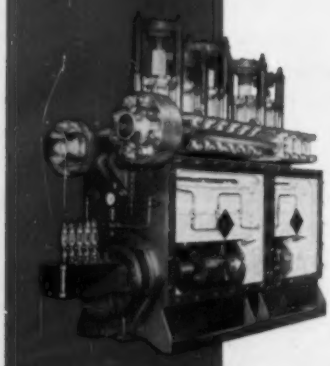
FREEZING OFF WATER-PRODUCING ZONES may be used as a temporary method of controlling intrusive water in air and gas drilling. The technique, being considered for water-control during the proposed construction of the England-France tunnel under the English Channel, might be used to form an ice-block in troublesome water zones in air or gas drilled holes.

INCREASED PRODUCER INCOME MEANS INCREASED DRILLING, especially in the last half of the year, according to Warren L. Baker, executive vice president of the AAODC. Writing in *The Drilling Contractor,* Baker forecasts that drilling activity may lag slightly behind 1959 rates during the first half of the year, but will expand sufficiently in the last six months to more than make up the difference. The first-half lag is blamed on unusually bad weather in many parts of the country and some delay in approving budgets among major companies.

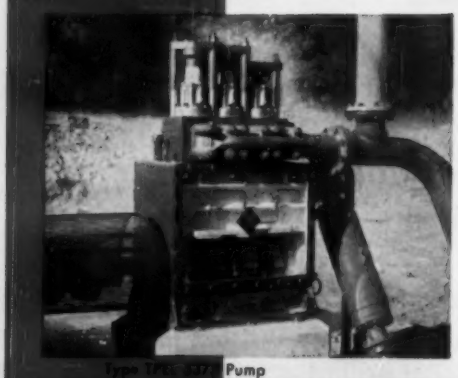
Today...tomorrow and Always-



Triplex Pump



Quintuplex Pump



Type TPE-337 Pump

A FULL DOLLAR'S VALUE FROM AJAX *Equipment*

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BY AJAX

Even in these days there are still some ways and places to obtain as much value for your dollar as you ever did.

One of these ways is to purchase known and proven quality products.

Such as Ajax products . . .

Purchasing low priced and less than the best quality in products at today's inflated values means you lose even more when it must be replaced sooner at inflated values.

Today's high taxes and diminishing returns demand careful equipment investment more than ever before.

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Here's the answer for a truly efficient, all-purpose bridge plug — one so simply constructed, with no moving parts, that it will not fail mechanically — so positive in sealing action that you get a leak-proof seal under hydrostatic pressures as high as 13,000 psi — yet so versatile it will successfully accomplish the most difficult plugging operations as well as the easiest.

The McCullough Bridge Plug is an explosive-expansion plug made of drillable aluminum. It is set at the desired location by the power of expanding gases from within the plug. On permanent installations it will last as long as the pipe in which it is set. It is ideal for temporary plugging operations as it drills out quickly and easily with a rotary bit.

TAKE A LOOK AT THESE FEATURES

- Simple, one-piece, all-aluminum construction. Slips, reins, rubber packers and all hardened or moving parts that might impede drilling out have been eliminated.
- No slips to hang up or accidentally trip and set the plug while going in the hole.
- Makes a positive leak-proof seal under the heaviest hydrostatic or mechanical loads.
- Easier on the pipe than a slip-type plug.
- Because it's shorter and smaller in diameter it easily passes through tight spots, dog legs, etc., and saves rig time in running, locating and setting.
- Drills out easier and faster.
- Resists corrosion and electrolysis.
- Available in 37 sizes from 1¾" OD to 10¾" OD for tubing, drill pipe, casing and in open hole in hard formations.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

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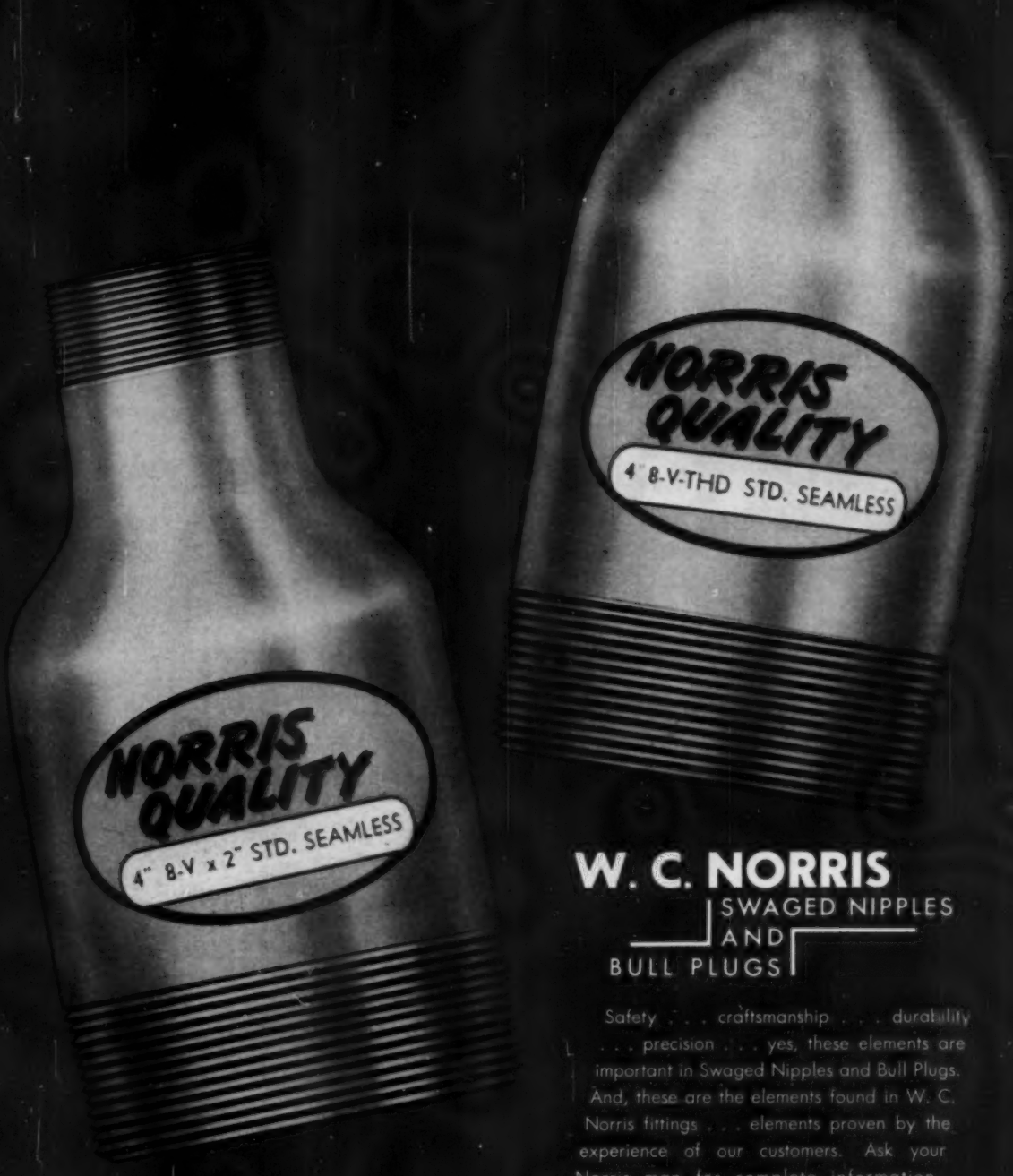

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Safety . . . craftsmanship . . . durability . . . precision . . . yes, these elements are important in Swaged Nipples and Bull Plugs. And, these are the elements found in W. C. Norris fittings . . . elements proven by the experience of our customers. Ask your Norris man for complete information.

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SUCKER RODS

• OTHER NORRIS CHAMPIONS

VALVES 150 PSI

WELL HEAD EQUIPMENT

Specially designed for rugged oil field duty

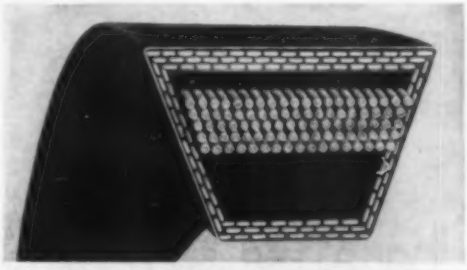
New Dayton BLUE-RIBBON® V-Belts

The New Blue Ribbon Thorobred V-Belt is not just a redesigned belt, but a totally new approach to V-Belt construction . . . new materials, new design, new specifications. It is a sturdy and powerful V-Belt, specially designed for the oil industry, that can withstand rugged, heavy duty service for a long time . . . with no "time-outs."

Check these outstanding features

- **Now, Blue Ribbon V-Belt** horsepower ratings are increased 40% over previous standard belts. Load carrying capacity is doubled. New super-strength, synthetic cords absorb machine killing shock loads and vibration . . . protect machinery . . . prolong belt life.

- **Extreme length stability** and precise manufacturing mean that belts can now be ordered in perfectly matched sets. Thus each belt pulls its share of the load increasing drive performance and bearing life.



Blue Ribbon Thorobred V-Belts are available in A through E cross-section industry standard sizes.

Find out how Blue Ribbon Thorobreds can increase your profit per job, write today to:

INDUSTRIAL DEPARTMENT

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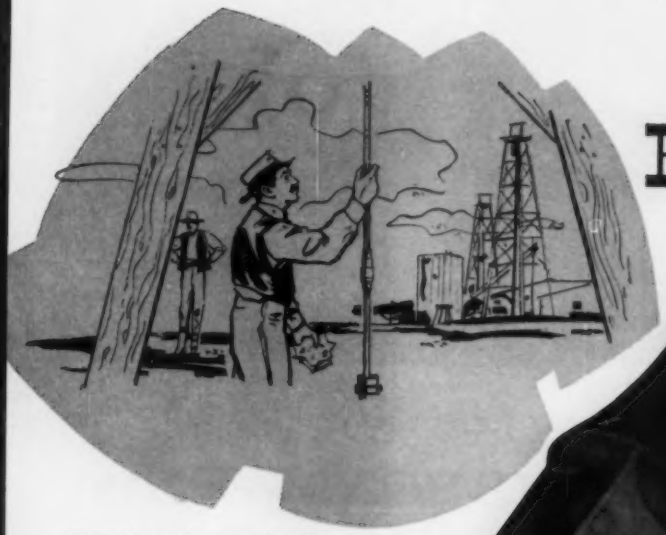
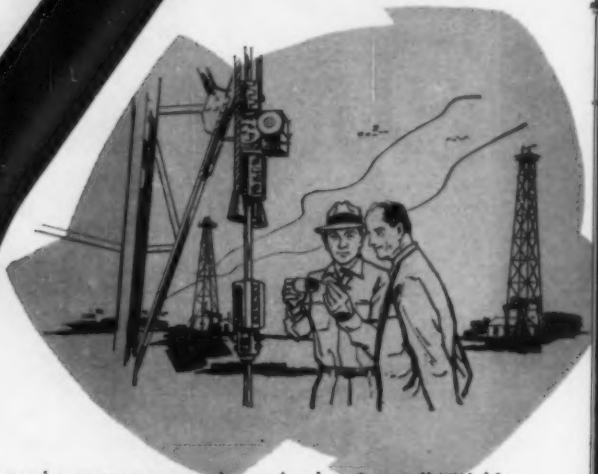
JONES

FIRST IN 1894...



The oldtimer's way of telling how a well was pumping was by feeling the polished rods. Long ago Jones developed more scientific methods to learn about the mechanics of pumping with sucker rods.

FIRST TODAY...



A good many years ago Jones developed a well weighing dynamometer plus the technical knowledge to diagnose the pumping problems of troublesome oil wells and to suggest remedial action. This is the type service you can expect from a **Sucker Rod Specialist!**

...because we're Sucker Rod Specialists!

There are four JONES JOB-ENGINEERED SUCKER RODS... a type for every pumping need!

THE S. M. JONES COMPANY

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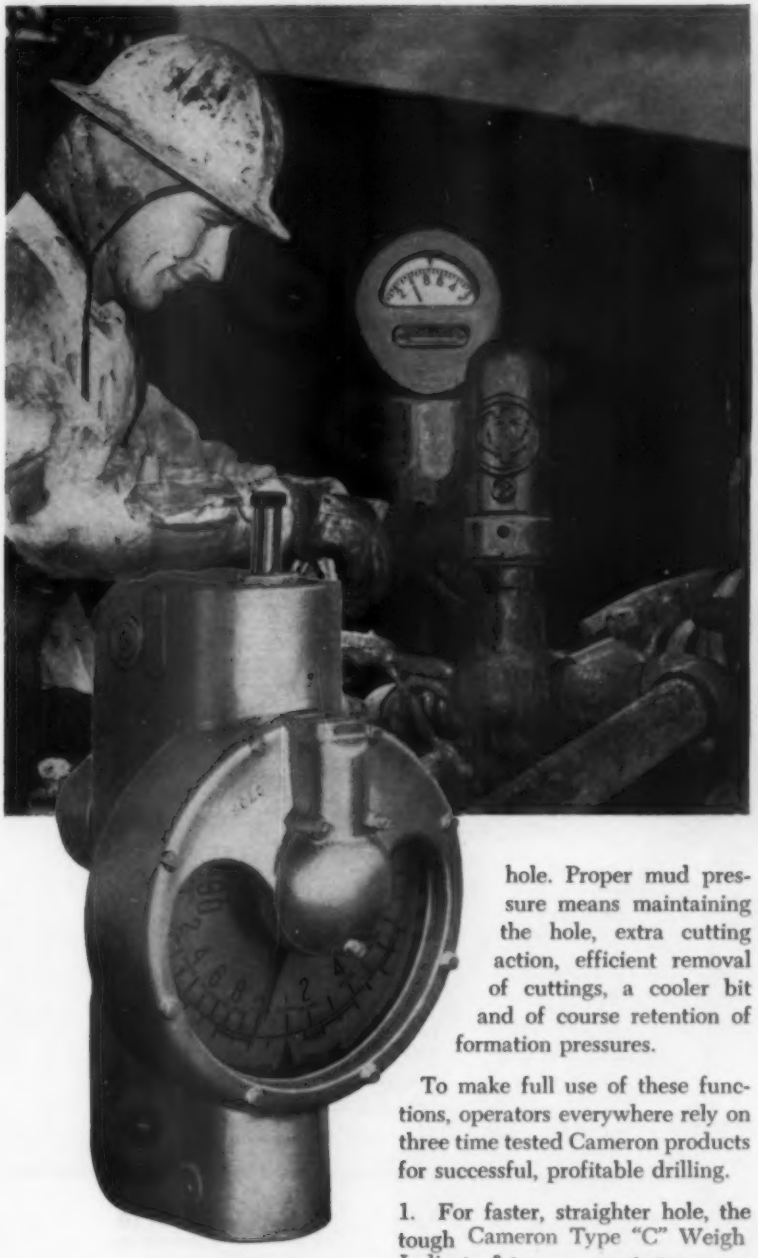

INDICATION OF HIGHER PROFITS

The success of your drilling operation depends on many things – two of these are weight on bit and mud pressure. An accurate indication of these forces is essential.

Proper weight on the business end of the drill stem means bits will bite better for fast, straight-down hole. Proper mud pressure means maintaining the hole, extra cutting action, efficient removal of cuttings, a cooler bit and of course retention of formation pressures.

To make full use of these functions, operators everywhere rely on three time tested Cameron products for successful, profitable drilling.

1. For faster, straighter hole, the tough Cameron Type "C" Weigh Indicator* has no equal. Temperatures in the field change abruptly from tour to tour but the Cameron Type "C" Mechanical Weight Indicator continues to register – accurately and dependably. The reason is simple – Cameron Weight Indicators have no hydraulic system to pick up or lose pressure with temperature changes. There is no possibility of breakdown due to leakage of high pressure fluids. The large yellow dial of the Type "C" with bold contrasting black and red numerals makes the indicator readily visible from any point on the rig floor. The indicator case is oil-filled (like the Cameron pressure gauge) to provide a viscous dampening of dial motion and to prevent damage from vibration.

2. Cameron Pressure Gauges* are found almost everywhere oil is found. Highly abrasive drilling mud under extreme, pulsating pressure will wreck an ordinary gauge in short order. But the self-contained diaphragm of the Cameron gauge prevents line fluids from entering the gauge mechanism. A unique dampening mechanism gives uniformly steady pressure readings without the usual violent fluctuations of conventional gauges. For offshore work Cameron pressure gauges are furnished with bronze cases. Standard models will handle mud, water, oil, air, and gas. Special models are available for almost any service, including corrosives.

3. Cameron Shear-Relief Valves shear a common nail (U. S. Standard) to relieve destructive pressure overloads. In drilling operations throughout the world slush pumps, manifolds and other expensive components are instantly protected by these reliable safety valves when desired pressures are exceeded. Any worker can choose the right nail with the handy hole chart on each Shear-Relief name plate.

To maintain peak efficiency in your drilling operations and top profits when totals are in – Count on Cameron.

*A convenient exchange policy allows credit toward the purchase of a new Cameron Weight Indicator or Pressure Gauge when repair is finally necessary.

Cameron

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Factories: Waukesha, Wisconsin, and Clinton, Iowa

"Born in Freedom — Working For Progress"

"This is the slogan adopted for oil's centennial year. It describes our industry well. Probably no other industry can boast the freedom for individual opportunity offered by the petroleum business.

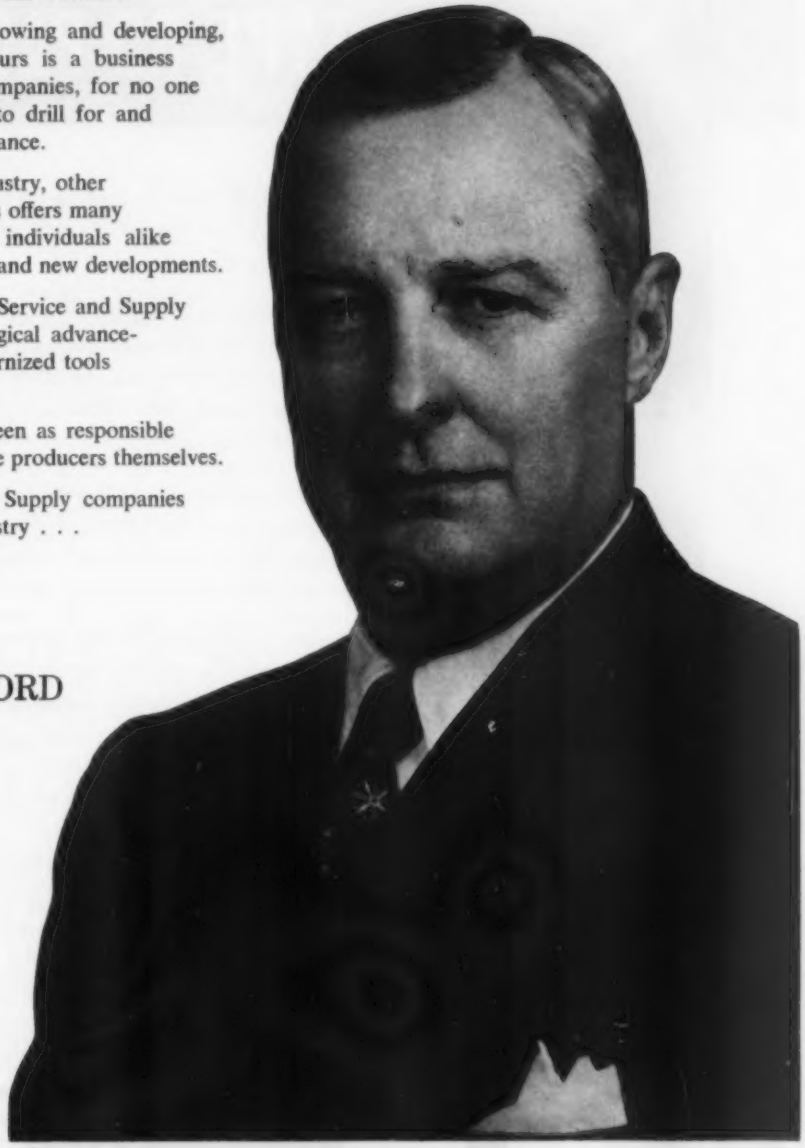
"Ours is a young business, still growing and developing, still inventing and progressing. Ours is a business comprised of many and varied companies, for no one producer is self-sufficient enough to drill for and produce oil and gas without assistance.

"Just as oil is important to all industry, other industries are important to oil. This offers many opportunities for companies and individuals alike to participate with ideas, processes and new developments.

"For instance, the Manufacturing, Service and Supply companies have given us technological advancements, better equipment and modernized tools to drill for and produce oil.

"In truth, these companies have been as responsible for the success of our industry as the producers themselves.

"The Manufacturing, Service and Supply companies typify the freedom of the oil industry . . . our progress is evident."



MR. W. K. WHITEFORD

President and Chief
Executive Officer
Gulf Oil Corporation

P.E.S.A.*

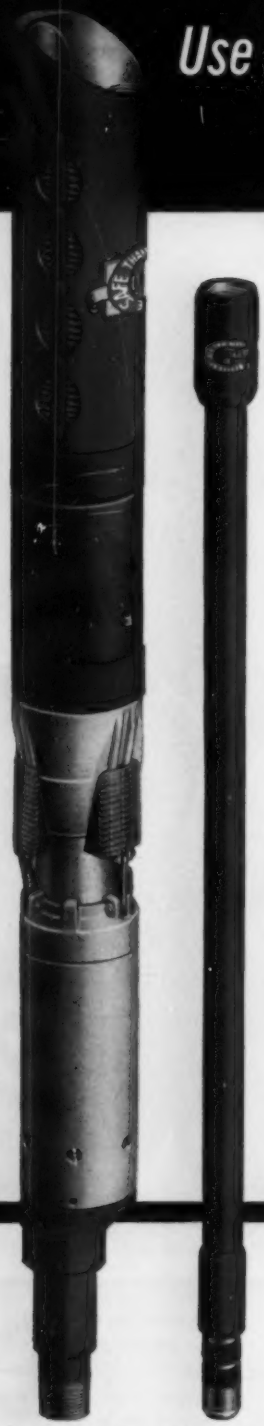
* PETROLEUM EQUIPMENT SUPPLIERS ASSOCIATION

PROUD TO BE PART OF A PIONEERING INDUSTRY

PETROLEUM EQUIPMENT SUPPLIERS ASSOCIATION

For Dual String Completions – Flowing or Pumping

Use GUIBERSON'S RETRIEVABLE TYPE RD PACKER



Type RD Packer with Anchor and Plain Stinger

This cleanly designed, rugged packer is an outstanding Guiberson development for dual string installations in wells of any depth.

Outstanding in performance because it operates perfectly with both zones flowing, high or low differential pressure; with either zone flowing, the other zone pumping; with both zones pumping; with either or both zones on gas lift; or for multi-zone injection — gas or water.

Outstanding in advantages because it completely isolates each zone from the other and from the casing; provides full opening long string to lower zone; permits either string to be pulled or run separately.

Guiberson's RD packer does complex dual zone jobs so well that operators tell us it's their best investment for dual string production. Ask your Guiberson representative about installation and auxiliary equipment recommendations.

Guiberson's RD packer has smooth operating dovetail slips of heat-treated alloy steel. Packing rubber is one-piece sleeve type — will not vulcanize in the well, made of Guiberson's special oil and gas resistant compound. You can get the RD packer with or without anchor, and a choice of stingers, plain or with snap-ring. Piston slips have extra large gripping area, are heat-treated alloy steel and keyed to anchor body up to maintain proper alignment. Get the Best — Get Guiberson.

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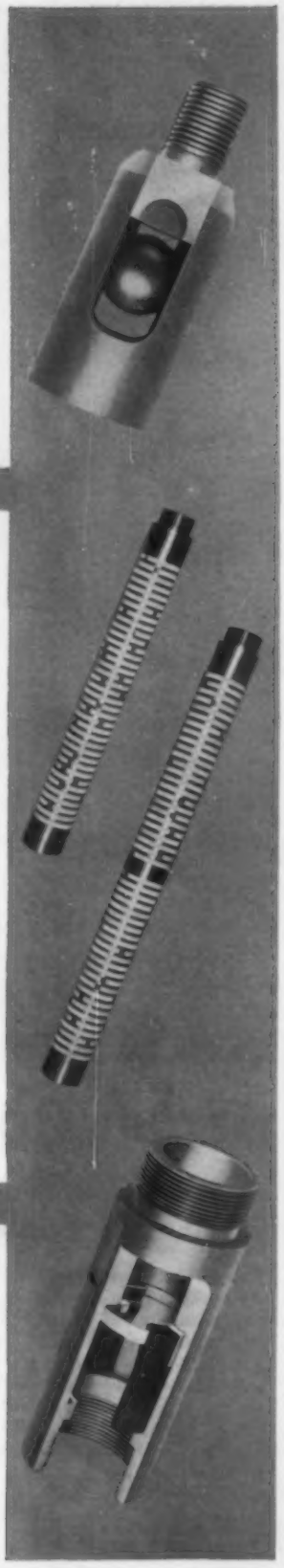

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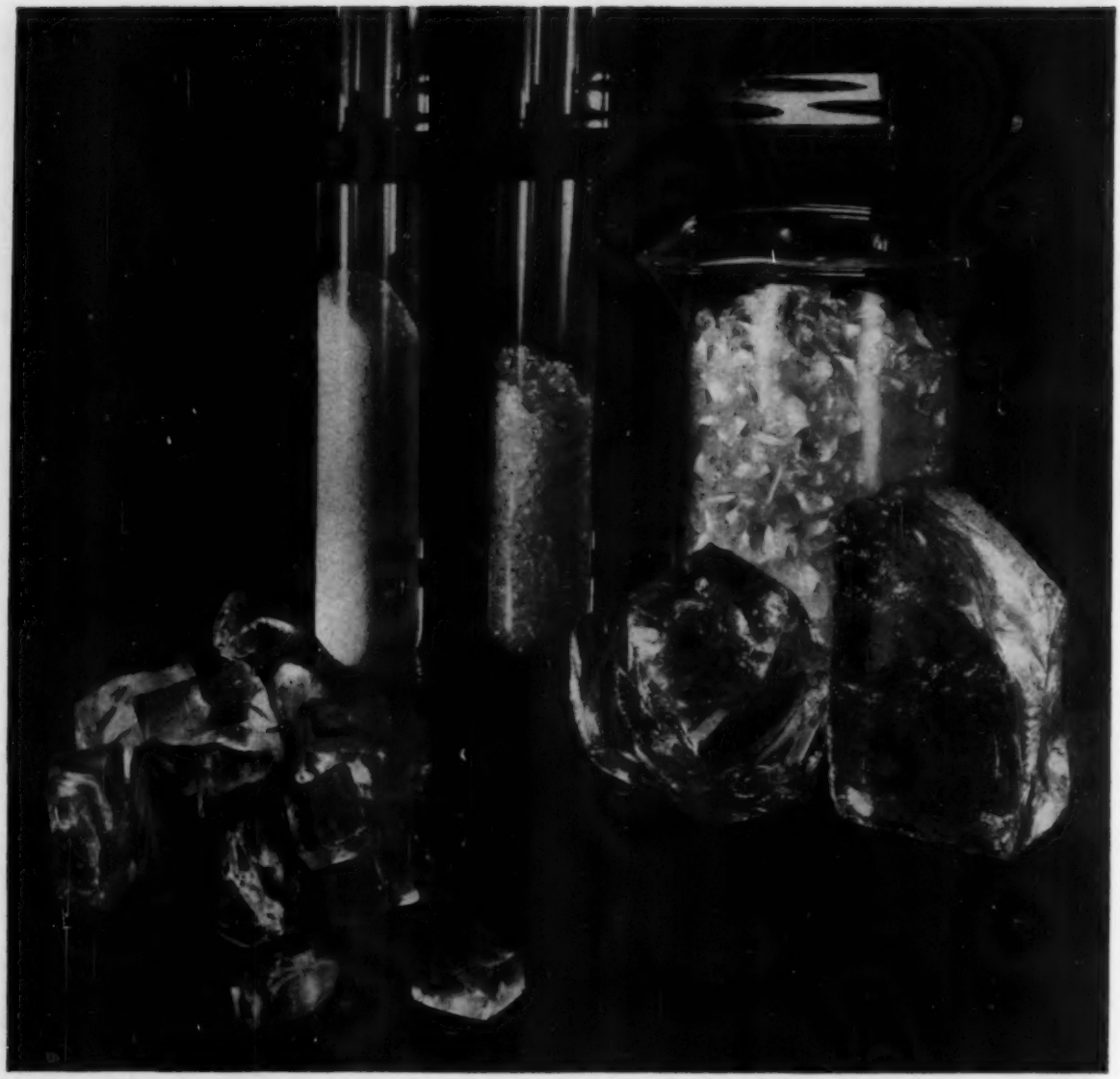

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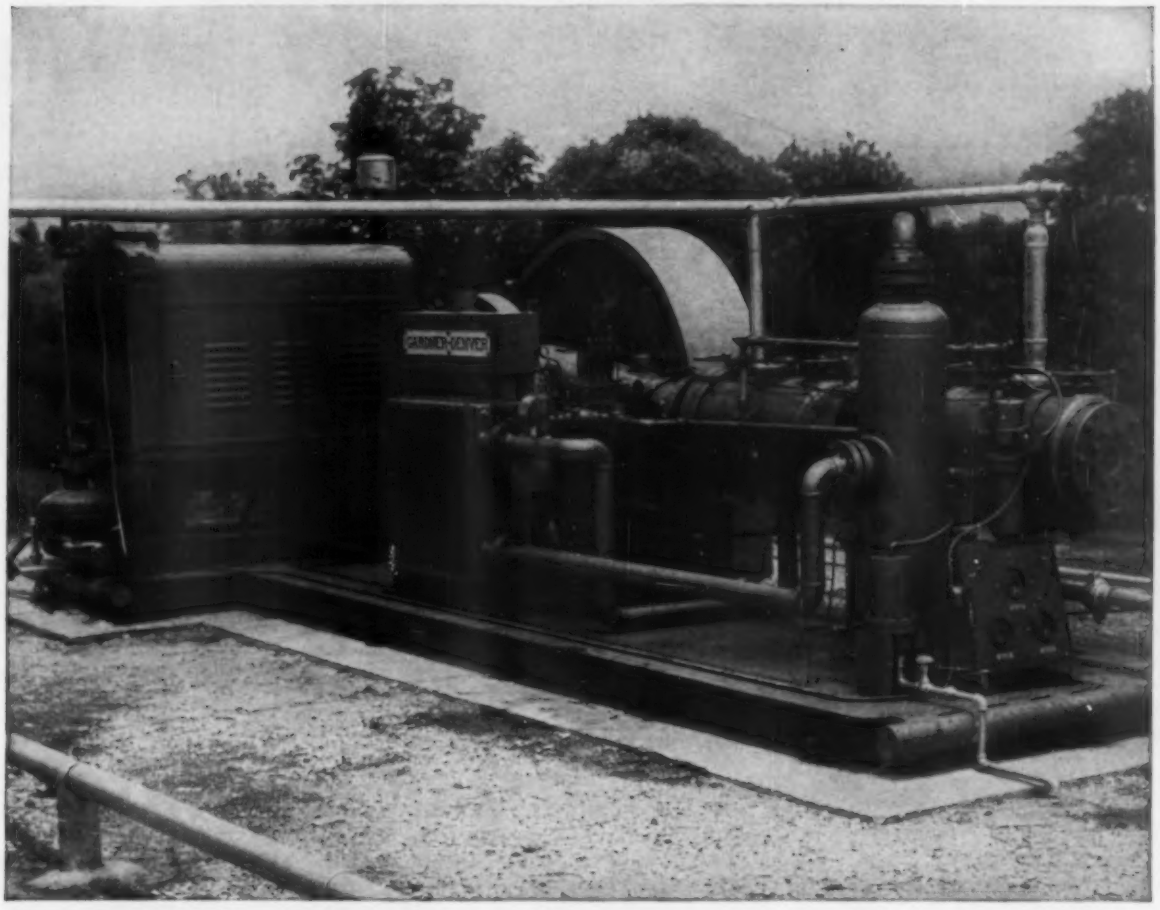

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Several thousand success stories speak for Baker Retrievable Bridge Plugs and the men who run them...

PRODUCT NO. 877-C

Why a retrievable bridge plug in the first place? The reason was a compelling one – there was a need to save time and money on certain important operations *(see right)*.

So a few years ago, Baker developed a new kind of bridge plug. Today, several thousand successful jobs later, Baker Retrievable Bridge Plugs have proved themselves to the satisfaction of operators the world over.

There's a reason for this success. Baker engineers have just one business – and that is designing oilwell tools. Likewise, Baker Servicemen have but one business – and that is running Baker tools. These are the things Baker concentrates on.

Superior tools and professional tool specialists to run them – it's a hard combination to beat. That is why so many operators look to Baker for tools and service.

The Facts About Baker Retrievable Bridge Plugs

WHY RETRIEVABLE BRIDGE PLUGS?

Baker designed them to fill a need for bridge plugs that could be set or reset any number of times without coming out of the hole. Without retrievable plugs, drill-up time alone would be a formidable cost factor in certain operations *(see below)*.

HOW THEY WORK

1 A Baker Retrievable Bridge Plug is run in on the Baker Full Bore Cementer – or by itself on wire line or tubing. Large bypass valves let it run freely.

2 Operation is simple and positive. Once in the hole and released, it sets and packs off automatically – no rotation is required.

3 Packoff is dependable. Two packing cups and two opposed sets of rocker slips hold pressure from either direction. When pressure differential reverses, the packoff reverses automatically.

WHERE AND HOW THEY ARE USED

1 They do many jobs. They see the most action in fracturing, acidizing, and squeeze cementing operations where they are teamed with the Baker Full Bore Cementer.

2 These are the bridge plugs that made conventional straddle tools obsolete. A Baker Retrievable Bridge Plug and a Full Bore Cementer can straddle virtually unlimited distance.

3 Because these plugs are so easy to pick up and relocate, any number of zones can be tested and treated in one round trip.

4 They are also used alone wherever a temporary plug is required down-hole.

5 They are used to plug off just below surface to keep the well under control when working over or testing well head equipment.

6 They are kept available as emergency equipment for offshore wells.

ARE BAKER PLUGS SUPERIOR?

For one thing, Baker Retrievable Bridge Plugs have two sets of opposed rocker type slips. In Baker's opinion, a retrievable bridge plug needs this extra holding power. Moreover, the plug is self-setting. Setting requires neither rotation nor pulling. Note this, too: the bypass valves have no ports or slots to plug up with mud, sand, or junk. They are full-opening 360° valves. These bridge plugs are simple in design, and are simple to operate. That is why they adapt with easy flexibility to the performance of many important operations.

BAKER

RETRIEVABLE BRIDGE PLUGS

BAKER OIL TOOLS, INC.
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Reduced costs result from . . .

Planning an Efficient Pumping Program

Control of pumping problems and related operating costs can be brought about by organized efforts of the operating personnel and is rewarding in many ways

C. J. Merryman, *Sun Oil Company, Midland, Texas*

INCREASING COSTS OF PUMPING equipment and service have created a greater interest in improving operating practices to obtain maximum efficiency. Recent statistics show that this interest is well placed, for stripper wells now represent 60 percent of the active wells in the United States. Many of these stripper wells are produced by sucker-rod pump systems, which means that a program designed to reduce operating costs must be capable of handling and eliminating problems of all classes of pumping wells from top allowable to stripper capacity.

Field experience has indicated that the program outlined in this article is adaptable to all phases of pumping problems and will pay substantial dividends through reduced operating costs and increased production.

PUMPING WELL PROBLEM ANALYSIS PROGRAM

Efficient and economic operations are the result of thorough problem analysis followed by proper equipment and operational adjustment to eliminate or minimize the cause of the problem. To obtain this goal, an operational program must contain and utilize the following factors:

1. Production team,
2. Planned test program,
3. Thorough repair operation,
4. Test and repair evaluation.

These factors may vary in importance, depending on the number of wells to be operated and the available personnel, but the failure to emphasize any one factor can disrupt the efficiency of the overall program. The following discussion will highlight the responsibilities and details involved in each section of the pumping program.

Production Team

The field production team consists basically of the superintendent, foreman or farm boss, engineer, and pumper. In many instances, certain conditions cause the responsibilities of this group to be delegated to one or two men. When this occurs, the effectiveness of the program depends not only on the capability of the men involved, but on the time available. Lack of adequate time to analyze the cause of pumping problems and make complete repairs can increase operating costs past all economic limits. The majority of field organizations include men in each of the categories mentioned. With this type of organization, a field superintendent can put a pumping well problem analysis program into effect quite rapidly by asking two questions:

1. Prior to pulling work — *What does the dynamometer test indicate?*
2. After pulling — *What was the cause of the problem and what was done to prevent it from occurring again?*

Consideration of these questions will indicate that accurate answers can be obtained only from a thorough test program that utilizes all available information.

An effective production team requires what might be called a continuous educational program. Each member must realize the importance of all information concerning the pumping well, the equipment, the production, and the problem. Each member should have the opportunity to present ideas concerning problems and various types of repair operations, and to review and evaluate the principles of pumping. This may be achieved through regular and special discussions on operations, problems, and new equipment. For example, the pumper probably knows more about the wells he operates than any other individual. He sees the detailed picture of the well operation daily such as fluid characteristics, operating problems, and signs of potential trouble. He is usually familiar with field problems and has made many visual inspections of down-hole equipment during pulling work. With this information he can contribute considerably to team knowledge and understanding.

These discussions will result in each member being able to assist the other in preparing for work that may be required. The foreman can make arrangements during installation of equipment to afford sufficient clearances so that the dynamometer or other tools can be installed and properly used. He can see that the pumping wellhead connections permit easy access to loading the tubing and checking pressures. This makes it possible for the engineer or tester to furnish the test data to the foreman rapidly and accurately.

Accurate records, tests, and problem studies are the responsibility of each member of the production team.

As various members of the production team are replaced, discussion sessions insure that new members are well informed concerning procedures, problems, and operations that will be their responsibility.

In many instances, manufacturers' representatives and service personnel

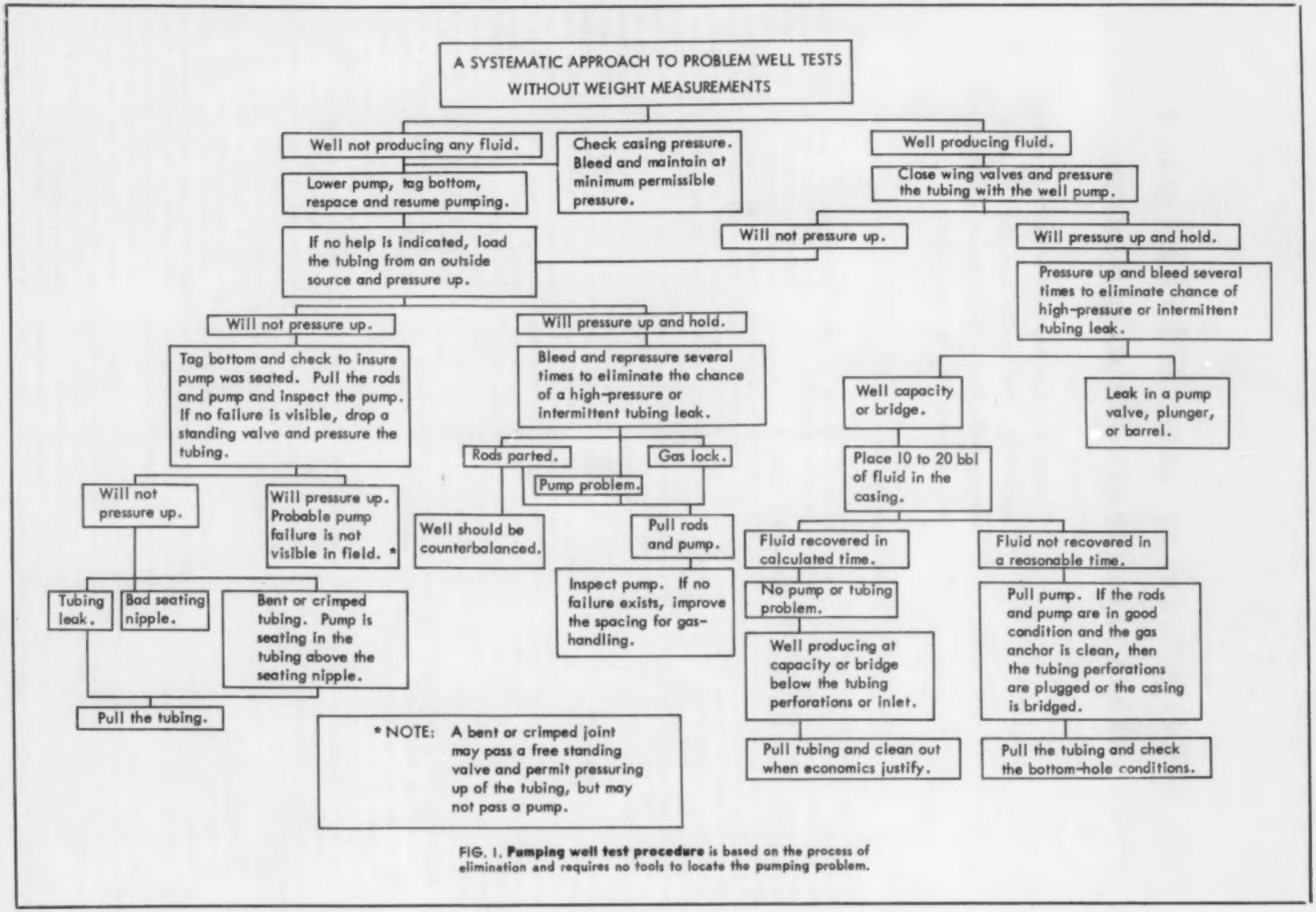
A SYSTEMATIC APPROACH TO PROBLEM WELL TESTS WITHOUT WEIGHT MEASUREMENTS
Well not producing any fluid.
Check casing pressure. Bleed and maintain at minimum permissible pressure.
Lower pump, tag bottom, respace and resume pumping.
If no help is indicated, load the tubing from an outside source and pressure up.
Will not pressure up.
Will pressure up and hold.
Tag bottom and check to insure pump was seated. Pull the rods and pump and inspect the pump. If no failure is visible, drop a standing valve and pressure the tubing.
Bleed and repressure several times to eliminate the chance of a high-pressure or intermittent tubing leak.
Will not pressure up.
Will pressure up. Probable pump failure is not visible in field. *
Tubing leak.
Bad seating nipple.
Bent or crimped tubing. Pump is seating in the tubing above the seating nipple.
Pull the tubing.
Rods parted.
Pump problem.
Gas lock.
Well should be counterbalanced.
Pull rods and pump.
Inspect pump. If no failure exists, improve the spacing for gas-handling.
* NOTE: A bent or crimped joint may pass a free standing valve and permit pressuring up of the tubing, but may not pass a pump.
Well producing fluid.
Close wing valves and pressure the tubing with the well pump.
Will not pressure up.
Will pressure up and hold.
Pressure up and bleed several times to eliminate chance of high-pressure or intermittent tubing leak.
Well capacity or bridge.
Leak in a pump valve, plunger, or barrel.
Place 10 to 20 bbl of fluid in the casing.
Fluid recovered in calculated time.
Fluid not recovered in a reasonable time.
No pump or tubing problem.
Well producing at capacity or bridge below the tubing perforations or inlet.
Pull pump. If the rods and pump are in good condition and the gas anchor is clean, then the tubing perforations are plugged or the casing is bridged.
Pull tubing and clean out when economics justify.
Pull the tubing and check the bottom-hole conditions.

FIG. 1. **Pumping well test procedure** is based on the process of elimination and requires no tools to locate the pumping problem.

can be included in the discussions. These men can always contribute to better understanding of pumping problems.

Planned Test Program

A planned test program is important for several reasons. First, accurate problem analysis is dependent upon a thorough test operation. Second, a planned program permits the work to be done quickly and repair operations can be completed with a minimum of down time. Third, each well test project presents an opportune time to study the well equipment and operation. The most important aspects of a planned test program are to complete the necessary tests and to analyze the problem at the location. Many problems are misinterpreted because the information is not studied in the field and is found to be incomplete when reviewed in the office.

The test program should be designed around the tools that are available. If no tools are used, a test procedure as

ANALYSIS RECORD OF SUB-SURFACE EQUIPMENT FAILURES

MONTH	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
YEAR												1958
DEPTH IN FEET												
2000	C											
4000												
6000			V							V & C		
8000												
LEASE												Sun Oil Co. "A"
WELL NO.												7
Costs: Motor Maintenance		25.25			199.43						2.62	
Motor Energy	15.00	15.00	17.60	18.20	17.60	17.60	17.60	17.60	17.60	17.60	17.60	17.60
OIL	1022	905	889	901	1020	981	997	1031	984	990	972	998
WATER	4200	3920	3830	4977	5921	5348	5471	5660	5570	5610	5502	5615
TOTAL FLUID	5222	4825	4719	5878	6941	6329	6468	6691	6554	6500	6474	6613
SPEED & STROKE	10 x 96"	10 x 96"	10 x 96"	10 x 96"	10 x 96"	10 x 96	10 x 96	10 x 96	10 x 96	10 x 96	10 x 96	10 x 96
PUMP SIZE	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"	1¼"

LEGEND

SUCKER ROD FAILURES: ● BODY; ○ PIN; ◐ COUPLING; ◆ UNSCREWED

TUBING FAILURES: △ BODY LEAK; ▲ COUP. LEAK; ⧋ PARTED; ⛤ PULLED FOR PUMP

PUMP FAILURES: ▣ PULLED & REPLACED; ▣ PULLED & REPAIRED; ▬ STUCK; ▬ PULLED ONLY

OTHERS: C - CORROSION; P - PARAFFIN; S - SCALE; W - WORN; M - Mechanical

SIZE TUBING 2" @ 6805
SIZE RODS 7/8 & 3/4
PUMP DEPTH 6755

FIG. 2. **Standard analysis form** used by Sun Oil Company presents a year's record of equipment failures, maintenance and energy costs, production, and equipment operation.

PULLING RECORD

DATE	LABOR	MATERIAL	TOTAL	REMARKS
1-21-58	$147.50	$ 15.00	$162.50	Replaced 1 - 25' sucker rod and placed back on pump
3-24-58	417.00	175.00	592.00	Tbg. leak - caliperd tbg. and replaced 8 joints, ran tbg. anchor
10-18-58	187.00	160.00	347.00	Plunger on pump worn and balls pitted by corrosion
Annual Cost	$751.50	$350.00	$1101.50	

FIG. 3. **Reverse side of analysis form** includes a record of pulling jobs, chemical treatment, and special services.

CHEMICAL RECORD		
DATE STARTED	TYPE	AMOUNT
1/25-Mar.	Corrosion Inhibitor	12 gals.
Apr.-June	Corrosion Inhibitor	16 gals.
July-Sept.	Corrosion Inhibitor	16 gals.
Oct.-Dec.	Corrosion Inhibitor	16 gals.
	Total	60 gals.
Annual Cost	Corrosion Inhibitor	$120.00

SPECIAL SERVICES		
DATE	DESCRIPTION - REMARKS	
3-24-58	Tbg. Caliper 6800' 2" tbg.	$340.00
Annual Cost		$340.00

Total Sub-surface Cost = Pulling, Chemical & Special Services $1561.50
Total Surface Cost = Energy & Maintenance $433.90

outlined in Fig. 1 can be followed. This system is designed to locate the pumping problem by the process of elimination. If the problem can be assigned to rods, pump, tubing, or well capacity prior to pulling work, then repair costs can be held to a minimum. Too many wells have been pulled two or more times in succession before the possibility of tubing leaks was ever considered.

If testing equipment can be obtained, the dynamometer is highly recommended. This instrument is believed to be the most complete and accurate pumping well test tool available. The dynamometer records a continuous diagram of the instantaneous polished rod load. This load record permits the analysis of both surface and sub-surface conditions. Pumping problems can be located more accurately by testing the well equipment in operation. The dynamometer makes this procedure possible. Many other tests such as pressure testing the tubing, checking casing and flow line pressures, and respacing the pump should be conducted along with the dynamometer test to obtain a complete picture of the well problem.

The planned test program should place the tester on the location, equipped with the proper tools and well information to analyze the pumping problem.

Thorough Repair Operation

Thorough repair operation simply means that whenever a well is pulled, every practical change which will improve the pumping system should be made. The well equipment will have been reviewed prior to pulling and any necessary changes can be quickly made, such as adding a larger gas-anchor, lowering the pump seat, or changing the polished rod to permit a greater hanger clearance. On many occasions pumps are pulled, repaired and re-run without considering the fact that production volumes have changed and a smaller pump would produce the necessary fluid with reduced loading and operating costs. These changes should be planned and then executed during the pulling operation.

After repair work is completed, operating adjustments should be made. Stroke length, pumping speed, counterbalance, and pumping time should be regulated to current needs. These changes should be recorded in order to keep well data up to date.

Test and Repair Evaluation

Follow-up tests should be conducted after repair or equipment changes in order to evaluate the corrected operation. Frequently several follow-up tests may be required to insure that new procedures are profitable and warrant use in other problem wells. Most procedure changes require a trial and error test program and the practical application involves both service life and cost.

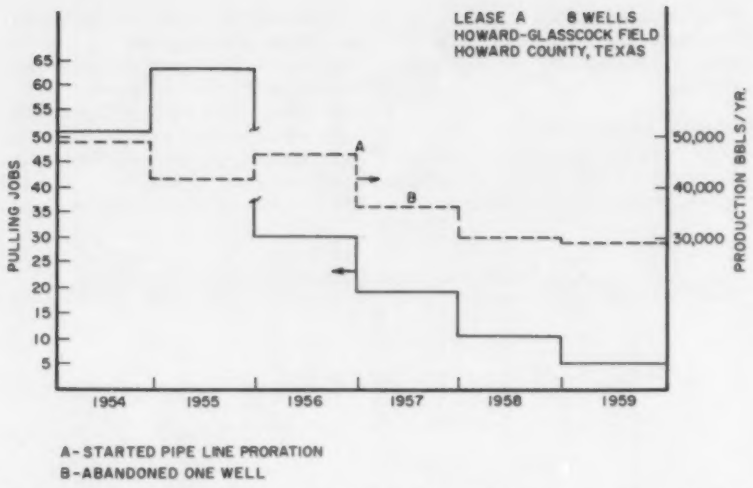

FIG. 4. **Typical results** of a field application of the problem analysis program are shown in this chart.

In addition to the follow-up well test, proper evaluation includes a continuous record of well costs. This cost record should include chemical treatments, special services, power, and maintenance as well as pulling costs. These costs, along with pertinent well data, can be incorporated into one form and be readily available to the foreman or any other member of the production team. A very complete paper covering the preparation and use of such a form was presented at the 1959 West Texas Oil Lifting Short Course under the title of "A Graphical Study of Pumping Wells" by Sun engineer, Bennie L. Franks. A copy of this form is shown in Fig. 2 and 3 to emphasize the simplicity of the form and the tremendous amount of information it makes available.

Results of a field application of the problem analysis program are shown in Fig. 4. The lease tested was an old lease where pulling work and old equipment problems were causing high operating costs. The degree of control of lease problems is shown by the reduction of pulling jobs. This correction was made possible by changing equipment and improving operations. A production increase of 29 bbl oil per day was obtained from three wells by increasing the pump capacities after dynamometer tests indicated these wells were not producing all the available fluid.

SUMMARY

The control of pumping problems and related operating costs can be brought about by organized efforts of the operating personnel. Tools and procedures are available to assist in this work and the results of planned pumping studies will be rewarding in many ways.

Acknowledgment

The author wishes to thank Sun Oil Company for permission to present this article and to thank Bennie Franks for his assistance in obtaining the example data.

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★ ★ ★

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He has co-authored a manual and several papers on pumping and pumping problems.

Key to efficient pumping . . .

Minimizing Slippage in Subsurface Pumps

Crude oil by-passing the plunger in your subsurface pumps is costing you money. Here is a method of analyzing your pumping operations to reduce slippage to a minimum

R. W. Reekstin
Axelson Division of
U. S. Industries, Inc.
Los Angeles, California

SLIPPAGE OF OIL past the plunger in subsurface pumps plays an important and necessary part in proper lubrication of the plunger. But when crude oil by-passes the metal plunger in excess of that vital amount, efficiency of the pump is decreased and horsepower is wasted. Reducing oil slippage rate can increase efficiency appreciably and result in a notable decrease in lifting costs.

Development of a simplified empirical equation and a graphic chart permit the determination of proper subsurface plunger fit and plunger length to minimize slippage. This simplified equation, although empirical in part, is actually based on an analytical formula derived from a mathematical relationship of flow between parallel and stationary plates.

Application of Formula

Substitution of five variables in the following empirical equation will provide a slippage rate past a pump plunger.

$$B_A = \frac{2.69hD^{0.8}S^{3.2}}{LY} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where h = fluid lift, 1000 ft
D = nominal plunger diameter, in.
S = plunger fit, 0.001 in.
L = plunger length, in.
Y = kinematic viscosity, centistokes

Fig. 1 may be used for converting bottom-hole viscosity, given in Saybolt Seconds Universal (SSU) to centistokes. The "h" term, fluid lift, can be generalized if necessary or the fluid lift can be assumed at the pump depth setting. The nominal diameter, "D", will be known or can be calculated, based on the production requirement. Use of the equation or charts will determine the best plunger fit, "S".

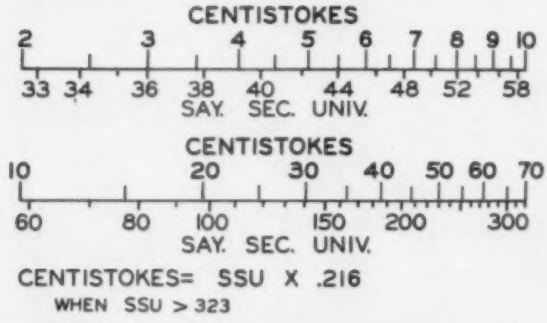

FIG. 1. Conversion chart is used to convert bottom-hole viscosity in Saybolt Seconds Universal (SSU) to centistokes. For values of SSU over 323, viscosity in centistokes is equal to 0.216 (SSU).

The equation has been solved in chart form in Fig. 2. Fluid lift to 10,000 ft, pump bore from 1 1/16 in. to 2¾ in., and plunger lengths from 4 ft to 7 ft can be readily analyzed. Use of Fig. 2 will result in a slippage rate based on a kinematic viscosity of 10 centistokes. A viscosity correction is made by multiplying the slippage value by 10 divided by the actual viscosity (10/centistokes).

Since bottom-hole viscosity is not always available, an estimate of viscosity must be made. Table 1 lists in very general terms API gravity crude with viscosity in centistokes. In using the chart, Fig. 2, no viscosity correction is required for 25 deg API crude, 10 centistokes.

Table 1. API Gravity vs Viscosity (Centistokes).

Gravity — Deg API	Centistokes	Gravity — Deg API	Centistokes
12°	605	23°	14
13	325	24	12
14	205	25	10
15	130	26	8.5
16	88	27	7.5
17	65	28	7
18	50	30	5.5
19	36	32	5
20	29	34	4.5
21	22	36	4
22	17		

A Typical Field Case

The following example makes use of Fig. 2 and Table 1.

Given: fluid lift – 6000 ft (h)
pump bore – 2¼ in. (D)
plunger length – 60 in. (L)
32-deg API gravity crude (Table 1)
400 bbl per day expected production

Assume a 2 percent slippage rate in order to provide proper plunger and barrel lubrication (8 bbl per day).

Solution. Table 1 shows 32 deg API gravity crude to have a viscosity of 5 centistokes. Ten divided by 5 (10/centistokes) results in a multiplicand of 2. This means that any slippage value found on Fig. 2 should be multiplied by 2. The chart should be entered from the upper horizontal scale, marked "5-ft plunger – bbl per day." Enter the chart at 4 bbl per day [4 × 2 = 8 (2 percent allowable slippage)]. Follow vertically down to the intersection of the 2¼-in. plunger curve. Follow horizontally across to the 6000-ft

fluid lift. Examination of this intersection will reveal the need for a minus 3-fit plunger.

Further examination of the chart as related to the problem reveals that slippage can be reduced by maintaining the minus 3-fit while increasing the plunger length.

The chart also shows the effect of wear on the plunger and barrel. After several months use, a 5000'ths-fit plunger may result. The initial 8 bbl per day slippage will have increased to 33 bbl per day. Hence, a faster surface cycle rate with an increase in horsepower will be required. At this time, the operator must decide to continue operating at the added power expense and increased load requirements, or replace the plunger to tighten up the fit.

Heavy-Crude Pumping

Heavy-crude constitutes a problem which operators have long faced. The approach is to utilize a closely fitted plunger if considerable amounts of sand must be produced. A slower cycle rate results because of a restricted plunger drop. However, longer pump life may be expected due to the wiping action of the plunger barrel.

Where the heavy crude is relatively clean, the plunger fit may be extremely loose and a short plunger may be used. These looser fits can be analyzed by the equation as follows:

Given: fluid lift – 2000 ft (h)
pump bore – 2¾ in. (D)
plunger length – 36 in. (L)
12 deg API gravity crude (Table 1)
300 bbl per day production
2 percent slippage rate (6 bbl per day)

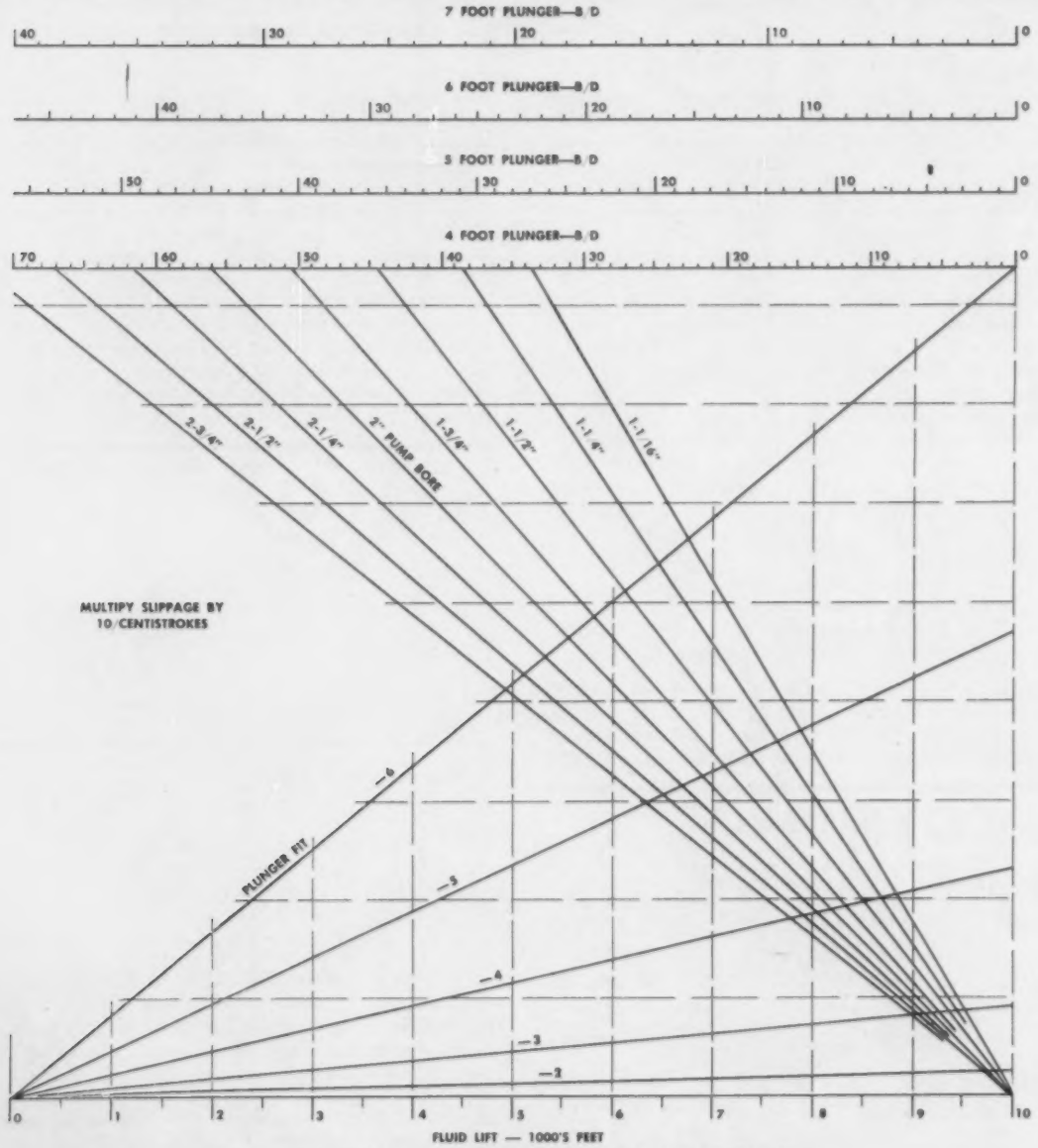

FIG. 2. Nomograph presents a graphical solution of the basic equation (Equation 1) used in determining oil slippage past the plunger in subsurface pumps.

Solution. "S" is the only unknown in Equation 1. Therefore, it may be rewritten, transposing terms.

$$S = \left(\frac{B_A L Y}{2.69h\, D^{0.8}}\right)^{1/3.2}$$

$$= \left[\frac{(6)\ (36)\ (605)}{(2.69)\ (2)\ (2.2463)}\right]^{1/3.2} = (1081.332)^{1/3.2}$$

$$= 8.874 \text{ (9 closely) thousandths of an inch}$$

The solution indicates the feasibility of a looser fit and shorter plunger length when viscosities are high.

Table 2 lists the $D^{0.8}$ and $S^{3.2}$ powers.

TABLE 2. $D^{0.8}$ and $S^{3.2}$ Powers.

D-in.	$D^{0.8}$	*S*	$S^{3.2}$
1 1/8	1.0493	2	9.2
1¼	1.1954	3	33.6
1½	1.3832	4	84.4
1¾	1.5647	5	172
2	1.7411	6	309
2¼	1.9131	7	506
2½	2.0814	8	776
2¾	2.2463	9	1131
		10	1595

Derivation of Slippage Equation

Any equation in order to be justifiable must have a basis. The aforementioned equation, although empirical in part, is actually based on an analytical formula from flow between parallel stationary plates:

$$Q_1 = \frac{P_1 b^3 d_1}{12 \mu_1 L_1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where Q_1 = leakage, cu ft per sec
P_1 = differential pressure, lb per sq ft
b = clearance between plates, ft
d_1 = width of plate perpendicular to flow, ft
L_1 = length of plates, ft
μ_1 = absolute viscosity, slugs per ft-sec or lb-sec per sq ft

The indicated terms do not lend themselves directly to expressions used in petroleum production, hence the following conversions are necessary:

$b = \frac{C_1}{24}$ where C_1 = diametral clearance, in.

$d = \frac{\pi D}{12}$ where D = plunger diameter, in.

$Q_1 = \frac{Q}{60} \times 1728$ where Q = leakage, cu in. per min.

$P_1 = 144\ P$ where P = differential pressure, psi

$\mu_1 = \mu \times 20.8855 \times 10^{-6}$ where μ = absolute viscosity, centipoises.

$L_1 = \frac{L}{12}$ where L = plunger length, in.

$$\text{Therefore, } Q = \frac{\pi\, DC^3 P}{2.32 \times 10^{-7}\, \mu L} \quad . \quad . \quad . \quad (3)$$

The above form does not take into account the existence of the pressure differential for only one-half the pumping cycle. In addition, pressure may be converted to fluid lift in feet and a specific gravity term added to accommodate various API gravity fluids.

$$B = \frac{0.439 \times 10^6 HDC^3 G}{\mu L} \quad . \quad . \quad . \quad . \quad (4)$$

where B = slippage, bbl per day (pressure differential for ½ cycle)
H = fluid lift, ft
G = specific gravity

Equation 4 has been accepted as a standard for computing pump slippage. Validity of the equation when applied to an oil well pump has been questioned by both Robinson[1] and Stearns.[2] Accordingly, tests were performed, and the results indicated a desirability for the modification of Equation 4.

An analysis of Robinson's results, by the writer, indicates the required addition of a constant multiplier and a change of exponents for the plunger clearance and diameter.

$$B_R = \frac{2.43 \times 10^6 HD^{0.7} C^{3.3} G}{L\mu} \quad . \quad . \quad . \quad . \quad (5)$$

where B_R = B = slippage, bbl per day (by Robinson data).

Stearns' treatment of slippage was based on an equation presented by Davis.[3] Controlled tests were then performed on the indicated variables. However, a check on the method of converting from the Davis expression to that used by Stearns indicated an error in the clearance exponent. The derivation which follows is corrected and checks dimensionally.

Basic Davis Equation

$$\left(\frac{g_c C_1}{2\rho V^2}\right)\left(\phi\right)\left(\frac{dP}{dL}\right) = \propto \left(\frac{\mu_2}{C_1 V \rho}\right)^f \left(\frac{D_2}{C_1}\right)^{\bullet}$$

. . . . . (6)

where g_c = acceleration due to gravity = 32.2 ft per sec²
C_1 = diametral clearance, ft $(D_2 - D_1)$
D_2 = outside annular diameter, ft
D_1 = inside annular diameter, ft
ρ = density of oil, lb per ft³
V = linear velocity of fluid, ft per sec
dP = pressure drop through annulus, lb per ft²
dL = length of annulus, ft
μ_2 = absolute viscosity of oil, lb (mass) per ft per hr
$\propto$ = proportionality constant, dimensionless
ϕ = viscosity ratio, dimensionless
f = exponent, + 1.0 for viscous flow
• = exponent, + 0.1 for viscous flow

The terms used by Davis are inconsistent with production usage, therefore, comparable equalities must be substituted.

Hence,

B_1 = slippage, bbl per day (pressure differential over full cycle)
K = constant
C = plunger fit, $(d_2 - D)$, in.
d_2 = diameter of liner, in.
D = diameter of plunger, in.
G = specific gravity
Y = kinematic viscosity, centistokes
p = differential pressure across plunger, psi
L = length of plunger, in.

The relation between units of the Davis and Stearns equations is:

$C_1 = C/12$; $D_1 = D/12$; $\rho = 62.4G$; $dP = 144p$
$dL = L/12$; $\mu_2 = 2.42GY$

Substituting in Equation 6:

$$\left(\frac{32.2(C/12)}{(2)\,(62.4)GV^2}\right)\left(\phi\right)\left(\frac{144p}{L/12}\right) = \propto \left(\frac{2.42GY}{(C/12)\,(V)\,(62.4G)}\right)^{1.0}\left(\frac{d_2/12}{C/12}\right)^{0.1}$$

Solving for V:

$$V = \frac{(79.9)\,(C^{2.1})\,(p)\,(\phi)}{(G)\,(L)\,(Y)\,(d_2^{0.1})\,(\propto)}$$

"B_1" expressed in terms of "V":

$$B_1 = V(d_2^2 - D^2)\,(84)$$

Therefore:

$$B_1 = (6.72 \times 10^3)\,(\phi/\propto)\left(\frac{C^{2.1}\,(d_2^2 - D^2)}{d_2^{0.1}\,(L)}\right)(1/GY)\,(p)$$

$$K = (6.72 \times 10^3)\,(\phi/\propto)$$

$$B_1 = K\left[\frac{C^{2.1}\,(d_2^2 - D^2)}{d_2^{0.1}\,(L)}\right](1/GY)\,(p) \quad . \quad . \quad . \quad . \quad . \quad (7)$$

A total of 28 individual tests were conducted by Stearns to determine the value of "K." However, because of a discrepancy of the "C" exponent (Stearns value was $C^{1.9}$) a new average "K" value has been computed. The new value is $K = 14.04 \times 10^6$.

The size factor portion of Equation 7 was simplified as follows:

$$\left[\frac{C^{2.1}\,(d_2^2 - D^2)}{d_2^{0.1}L}\right] = \frac{C^{2.1}\,(d_2 + D)\,(d_2 - D)}{d_2^{0.1}L}$$

where $(d_2 - D) = C$
and $(d_2 + D) = 2d_2$ (closely)

Therefore:

$$\frac{2C^{2.1}d_2^{0.9}}{L} = \text{size factor}$$

Also, $p = 0.433\,HG$
where H = differential pressure expressed in ft of oil

A divisor of 2 must be used in order to compensate for a pressure differential for only one-half cycle:

$$B_a = \frac{B}{2} = \frac{(6.08 \times 10^6)\,(C^{2.1})\,d_2^{0.9}HG}{LYG} \quad . \quad . \quad (8)$$

Of the three equations presented, Equation 4, which is analytical in construction, is the least accurate. The equation does not compensate for surface irregularities, change of viscosity in plunger length due to frictional heat, and failure of plunger to operate concentric to the liners. The use of the constant and exponent modification as indicated in the Robinson and Stearns equations presumably have compensated for these irregularities.

It is the writer's thought that insufficient tests, due primarily to lack of time and material, constitute the major difference between the Robinson and Stearns equations. Equation 1 is an average of the difference between the two equations. In addition to being a compromise between the two, it also has been reduced to more easily handled terms.

References

1. Bruce H. Robinson, "Economics of Pumping," Drilling and Production Practice, 91-6 (1935).
2. Glenn M. Stearns, a progress report, "An Evaluation of the Rate of Slippage of Oil Past Oil-Well Pump Plungers," Drilling and Production Practice, 25-33 (1944).
3. Elmer S. Davis, "Heat Transfer and Pressure Drop in Annuli," Trans. Am. Mech. Engrs. 65 [71] 755-60 (1943).

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API's Southwestern District Selects New Officers

THE SPRING MEETING of the Southwest District, Division of Production, American Petroleum Institute was held March 2-4 in Dallas, Texas. Election of new officers resulted in the appointment of Henry Kerr, Delhi-Taylor Oil Corporation, Dallas, as district chairman. Kerr's predecessor, L. L. McDonald, The Pure Oil Company, Fort Worth, was elected chairman of the district advisory committee. Henry P. Shackleford, Tidewater Oil Company, Hobbs, N. M., was elected district secretary-treasurer.

District vice chairmen elected during the meeting and their areas of responsibility are J. W. Sallee, Cardinal Chemical Company, Midland (West Texas); Charles Foster, Gulf Oil Corporation, Wichita Falls (North Central Texas); George Geyer, Cities Service Oil Company, Hobbs (Southeastern New Mexico); Al Greer, Benson-Montin-Greer Drilling Corporation, Farmington, N. M. (Northeastern New Mexico); E. C. Mlcak, Standard Oil Company of Texas, Gainesville (Northeast Texas); and C. E. Smith, The Western Company, Lubbock (South Texas).

Henry Kerr, left, general superintendent of production operations for Delhi-Taylor Oil Corporation, Dallas, has been chosen to head the API's Southwestern District for the coming year. Kerr succeeds **L. L. McDonald**, right, assistant Fort Worth division manager, The Pure Oil Company, who was elected chairman of the District advisory committee.

WHAT YOU ARE ABOUT TO READ

This article will be published in two parts. Following is a topic outline of the material to be covered in both parts of the article:

PART 1

I. Possible methods of artificial lift in slim holes
- A. Gas lift
- B. Plunger lift
- C. Sonic pump
- D. Down-hole hydraulic pump
- E. Scaled-down conventional
- F. Casing pump
- G. Hollow rods

II. Choice of method
- A. Application intended
- B. Factors involved
- C. Agreement with slim-hole concepts
  1. Initial cost
  2. Operating cost

III. General points about possible methods

PART 2

IV. Most popular installations
- A. Scaled-down conventional
  1. Limits
     a. Capacity
     b. Depth
  2. Paraffin and sand control
  3. Cost to install and operate
  4. Repair and maintenance
- B. Hollow rods
  1. Limits
     a. Capacity
     b. Depth
  2. Paraffin and sand control
  3. Cost to install and operate
  4. Repair and maintenance

V. Conclusions and comparisons
- A. Operator's option
- B. Application intended
- C. Special problems

Various types of . . .

Pumping Installations in Ultra-Slim Casing

PART 1. *There are several methods of pumping wells with 2⅞-in. casing. Two of the most popular methods are the scaled-down conventional method with tubing and rods and the use of hollow sucker rods*

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YOU'VE HEARD THE EXPRESSION, "There's more than one way to skin a cat." Well, there's more than one way to lift fluid in 2⅞-in. casing, too!

Someone once observed, "People will apply according to need or demand." This observation has considerable merit when you consider this fact: "When faced with the need to artificially lift a 2⅞-in. cased well, an operator might choose from the following list of lifting methods. His final choice is going to be based on individual well conditions and his own judgment.

A. A gas lift system, either continuous or intermittent flowing up through small diameter tubing.

B. A plunger lift system using the reservoir energy and the casing as a flow conduit.

C. The "sonic" pump of recent development, again with small diameter tubing.

D. A hydraulic down-hole pump producing through the tubing-casing annulus while being driven hydraulically by power oil from surface.

E. A reciprocating down-hole pump, rod driven from surface, inserted into or whose barrel is mounted in small diameter tubing.

F. A casing pump anchored to the 2⅞-in. casing and rod driven from surface.

G. A reciprocating down-hole pump driven by a hollow rod which serves as a conduit to surface and as a mechanical link to surface.

Choice of Method

As the observation states, "People will apply according to need or demand."

There is one very simple but very, very important fact about slim-hole completions: There is no *right* or *wrong* way to pump them. It all depends on how much money you want to spend, what you want to accomplish, and what possible operational problems you might expect while producing your well.

Many factors enter into the picture as a method of artificial lift is chosen and the associated equipment is selected to fit the method and well conditions. Among these factors are cost of the installation, established company practice, management attitude toward various lifting methods, operator's past experience, and immediate need or demand for a particular type of installation. The above mentioned factors might be described as "atmosphere" factors surrounding an installation selection. Notice that they do not directly relate to engineering principles. The point is this — a well with any size casing, slim-hole or conventional, may be completed using some artificial lift method for a variety of reasons, some of them without regard to good engineering practice. If this is the case, the engineer has little control over the money spent, the method used, or the equipment purchased. In short, the installation is simply based on past standards.

One of the basic concepts behind slim-hole techniques is to complete an oil or gas well using minimum investment while retaining ability to produce allowable hydrocarbons and, thus, maximum income. To accomplish this goal a slide rule and some gray matter must be applied to the problem of artificial lift inside of each 2⅞-in. completion. The objective is the selection of a method which will give relatively low initial cost, efficient performance, and a good maintenance history. Keep in

mind that lowest initial cost does not mean that you have the answer because that particular equipment may prove insufficient and short-lived.

Some of the things that must be considered before a selection can be made are (1) sand produced with the crude, (2) gyp or salt deposits on or near pump parts, (3) paraffin deposits on pumping parts, (4) depth needed to reach fluid, (5) daily capacity, (6) water cut, (7) gas-oil ratio, (8) weather conditions, (9) nearness of operating personnel to the lease (in very remote areas) and (10) the need for fail-safe installations in hazardous areas. When the facts concerning these and other items are known, a dependable pumping installation can be ordered out to the lease.

What About the Methods Available?

When sufficient information is known about well-bore conditions, an appropriate lifting method can be applied.

Some general comments about the various methods might be of help before a choice of method is made.

Gas lift. Here is a good low maintenance lifting method if the system is well designed at the start of an artificial lift program.

Gas lifts lend themselves to low pour point crudes where sediment and dirty conditions do not exist. Of course, a source of high-pressure gas and compressor equipment is needed. For this reason gas lifts are most applicable where a group of wells can be lifted with compressor equipment at a central point. These installations can be very expensive when all the equipment is taken into account. High-pressure piping, large capacity separators and, in some cases, well head heaters are required.

There may be trouble in some areas due to rules and regulations concerning the application of high-pressure gas on a 2⅞ by 1-in. annulus. Protection against casing leaks is, of course, lacking and should be considered. An alternate method here could be the use of inert gas generators to avoid dangerous conditions through the use of natural gas. In large groups of wells this should be investigated.

In a conventional gas-lift system, the lifting medium is natural gas which is salable and two choices exist. Either separate and sell or separate and recycle. The choice depends on market and gas availability.

Plunger lift. There will be limited use of plunger lift in 2⅞-in. cased wells. Normally this technique is used to control gas-oil ratio of flowing wells and to extend the flowing life of a well. It is at best an interim measure between flowing life and artificial lift.

Sonic pump. This method is relatively new and shows promise of application where sand or gyp are a problem. Since there is no down-hole pump involved, pump repairs are eliminated. The many valves used in the rapidly reciprocating string should give long life. There can be an excess number of valves installed initially so that a leaking valve later on will be made up for by one of the extra valves.

The major drawback appears to be keeping the string of pipe together. Fatigue failures of tubing joints are the major maintenance problems. It appears that only part of the string moves at a time and fairly high frequency elastic waves are set up in the tubing. So long as the endurance limit of the connection is not exceeded, it should work. Possible casing or tubing wear should be kept in mind when considering this method. The advantages of no down-hole pump and simple surface equipment make this method attractive.

Hydraulic down-hole pump. Three types of hydraulic down-hole pumps are available or are being designed for use in 2⅞-in. casing. This method should provide a relatively low down-time installation since the pump is linked hydraulically to surface rather than mechanically. Such hydraulic linkage serves to absorb shock loads and thus prevent high stresses. This, in turn, should and does reflect a lower down-time and repair costs.

Where just one or two wells are to be pumped, the system can be expensive. It lends itself better to groups of wells where a central prime mover and pump can be installed to power the entire group. These units can be rigged to produce up to 660 bbl per day at shallow depths and somewhat lesser capacities can be produced from depths as deep as 10,000 ft. For deep and/or high volume production, they are a logical choice. Casing wear is not a problem with these units. From a theoretical standpoint, a down-hole hydraulic pump is ideal since it puts the device producing pumping power at the bottom of the hole where it belongs. Some of the drawbacks are that produced crude must be conditioned for use as power oil and the inherent inability to vent gas from the formation.

Small tubing and rods. Here is the old stand-by for pumping purposes. Field men seem to choose this hook-up by sheer momentum of operations. Literally speaking, they are used to it. Although rods and tubing installations handle gassy crude situations well, they involve a considerable amount of iron in the hole which makes for rough fishing jobs. Two drawbacks of small tubing and rods are their limited pumping and depth capacities and troublesome operation while handling sand or paraffin. Tubing and rods offer a fairly reliable method of production and minimize 2⅞-in. casing wear.

Casing pump. A rod driven casing pump offers a cheap, high volume lift method. An operator is faced with dangerous wear problems, no capacity for gas venting, and costly pulling and/or fishing jobs where sand, gyp, scale, or paraffin are involved. Generally speaking, a casing pump is considered only as a last resort for installation where high volumes are needed and wear is not considered vital to the life of the well.

Hollow rods. In terms of equipment and problems, the hollow rod splits the difference between a tubing and rods installation and a casing pump. The hollow rod provides a passage to conduct oil, water, solution gas, sand, gyp, and paraffin to surface and at the same time keep the more troublesome particles out of the annulus where such deposits can freeze the pump. Should fishing become necessary, only one string is there to be caught making the hollow rod an easy fish. The hollow rod, of course, serves to power the down-hole pump while conducting fluid, thus serving the function of tubing and rods at the same time.

The rod-casing annulus is normally used for venting gas or for circulating hot oil to control paraffin. Internal plastic lining provides effective paraffin control and minimizes hot oil treatments except in extreme weather conditions.

The hollow rod inherently keeps the fluid velocities high and thus carries sand and other particles to surface without trouble.

The roles of rod and annulus can be reversed to vent gas up the rod while producing up the annulus. There are some loading advantages in this technique which can affect power requirements depending on the type of surface pumping unit. Buoyancy of the gas-filled rods offers some advantages when using a hydraulic pumping unit.

Although an operator can lift fluid in 2⅞-in. casing by many methods, in practice most will complete by one of two methods. The two most popular choices are the hollow rod and the tubing and rod systems. The reasons for these frequent choices are most probably due to the fact that more is known about them than any other method.

To Be Continued

Part 2 of the article deals with each of these methods, the forces involved, the production and depth limitations, and the relative costs of each. * * *

10,000 ft and below . . .

Deep Well Pumping Methods

The deepest well presently pumped by sucker rods has the pump at 13,200 ft. But at least one operator anticipates the need of pumping a well from 17,000 ft

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WHEN IT BECOMES NECESSARY to put an oil well on the pump, the operator is faced with an investment of several thousand dollars in some means of artificial lift. As wells go deeper and deeper the problem becomes increasingly more difficult. By far the most successful and most generally accepted type of artificial lift is with the use of sucker rods. The world's deepest well pumped by sucker rods is located near Lovington, New Mexico, in the Caudill field. (See Fig. 1.) The pump setting on this installation is 13,200 ft. The pump size is 1 1/16 in., tubing is 2½ and 2 in., rods are 1, ⅞, and ¾ in., stroke length is 168 in., and the unit has a pumping speed of 9 strokes per min. This well is being pumped with a beam unit having a structural rating of 32,000 lb. It has a 912,000 in.-lb gear reducer and is equipped with a combination crank and beam counterbalance. The well is producing 125 bbl per day.

When considering the problems of deep well pumping, the surface equipment usually selected is either a long stroke crank-balanced unit or a long stroke air-balanced unit. Before discussing the relative advantages of each of these types it might be well to investigate some of the basic requirements necessary to produce oil from 10,000 ft and below.

Production and Stroke Length

In calculating production on a deep well, it immediately becomes apparent that a long stroke is an absolute necessity if large fluid volumes are expected. Examining the calculations we note that one of the big reasons why a long polished rod stroke is needed is the stretch of the sucker rod string itself. As we increase plunger size in an attempt to offset the effects of this stretch, we often find that we have made matters worse by further increasing the stretch to the extent that production is actually decreased and rod stress increased. We may then attempt to offset the stretch by increasing the pumping speed of the unit. Here again we often run into trouble as the sucker rod stress increases beyond reasonable limits. The farther the problem is pursued the more we find ourselves going to longer and longer strokes and at the same time operating at slower pumping speeds.

In order to emphasize this point, refer to Fig. 2. The curve shown is a

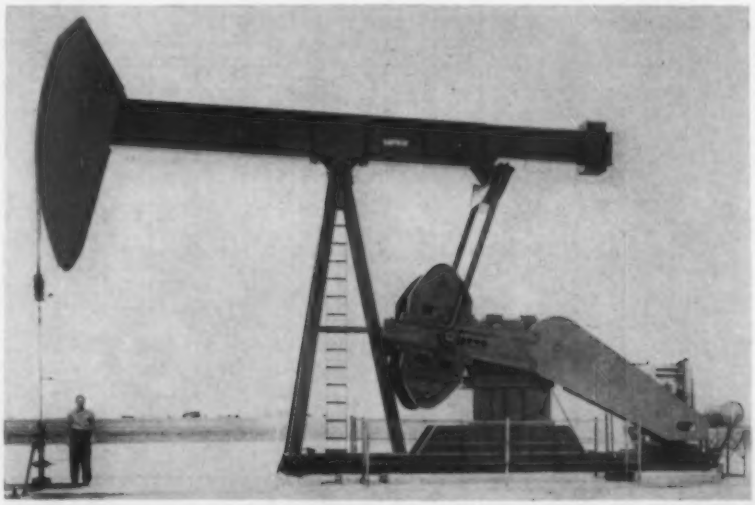

FIG. 1. Crank counterbalanced pumping unit, simplest of all types of pumping units utilizing a sucker rod string, is installed on the world's deepest well pumped by sucker rods in which the pump is set at 13,200 ft.

plot of production against stroke length for a hypothetical well of 10,000 ft with a tapered string of 1, ⅞, and ¾-in. rods and with a 1¼-in. pump. This curve assumes that ample fluid is available and that the only limitation to production is sucker rod stress. In this example, rod stress is limited to 35,000 psi. The curve shows that production can be increased from 88 bbl per day with a 44-in. stroke operating at 17.9 spm to 256 bbl per day with a 20-ft stroke operating at 7.6 spm. This, of course, does not mean that this increase in production could be accomplished with the same size pumping unit but merely illustrates what can be produced from a well where sucker rod stress rather than well potential is the design criterion.

It might also be wise to look at this problem of production and stroke length from a slightly different angle. Consider a well of 11,000-ft depth from which production of 200 bbl per day is required. Let us assume a 1¼-in. plunger and 1, ⅞, and ¾-in. rods. Table 1 shows how this production can be obtained with a 100-in. stroke unit, a 168-in. stroke unit, and a 240-in. stroke unit. Note that as the stroke length is increased, rod stress decreases and the strokes per minute required to obtain the desired production decrease. As will be pointed out, a reduction in rod stress, even if small, and a reduction in strokes per minute will increase rod life to a very great extent as well as reduce costly down time.

TABLE 1. Production Calculations — 11,000 ft.

Stroke, in.	SPM	Prod. bpd	Max. Load (lb)	Load Range (lb)	Rod Stress (psi)	Peak Torque (in. lb)
100	13.7	200	31,500	17,950	40,200	531,000
168	8.9	200	29,750	14,490	37,900	716,000
240	6.35	200	28,600	12,170	36,450	860,000

Sucker Rod Stress

One of the greatest advantages to be gained from a unit with a long polished rod stroke is the greatly increased life of the sucker rod string. Since sucker rod failures are invariably fatigue failures, it is apparent that in a highly stressed string of rods that will ultimately fail in fatigue, fewer stress reversals per given length of time will lengthen the life of the string proportionately. Note in Table 1 that for a given production the pumping speed decreases in nearly direct proportion to the increase in stroke length. We could therefore expect over twice as many rod breaks on the string operating at 13.7 spm as with the string pumping at 6.3 spm.

Also note in Table 1 the reduction in rod stress with an increase in stroke length. This reduction in stress can be very significant. Very often a relatively small decrease in rod stress can virtually cure a seige of rod breaks.

The exact value of the maximum allowable sucker rod stress has always been a point of conjecture. There is no pat answer, even with a given make and type of rod. The maximum load and the load range has a great effect on the life of any rod string. For example, with a particular make of sucker rod the allowable stress recommended by the manufacturer varies from 36,600 to 48,500 psi depending entirely upon the maximum load and load range. (The load range as used here is defined as the difference between the maximum load and the minimum load.) As the stroke length of a unit is increased we have seen in Table 1 that the maximum load and the load range decreases for a given production. Thus, as we lengthen the stroke we are able to utilize to a greater extent the maximum allowable stress values of any particular make of sucker rod.

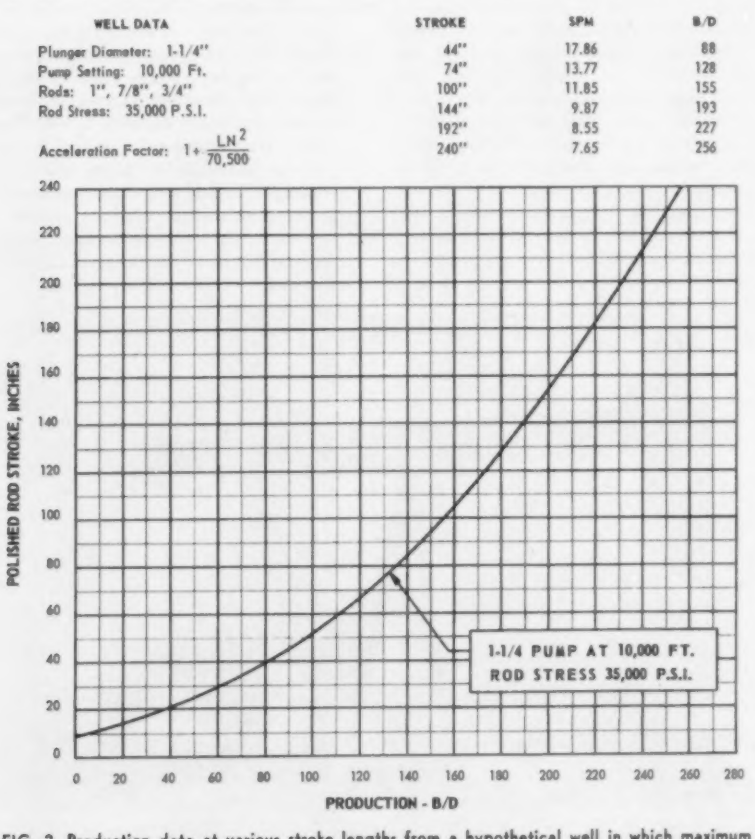

FIG. 2. Production data at various stroke lengths from a hypothetical well in which maximum rod stress is limited to 35,000 psi. Curve shows production as a function of polished rod stroke with a 1¼-in. pump at 10,000 ft.

Pumping From 17,000 Ft

Generally speaking, the term "deep well pumping" would apply to wells which are being pumped from 10,000 to 12,000 ft. As wells are being drilled to greater and greater depths, however, it may very well be that the 10,000 to 12,000-ft wells will be classified as "medium depth" in the near future. A midwestern operator, for example, anticipates the need of pumping a well from 17,000 ft! Table 2 shows how a 20-ft stroke air balanced unit operating at 5.5 spm could deliver 130 bbl per day from 17,000 ft with the help of 2-in. standard tubing as the top part of the rod string. As the table shows, the buoyant force on 7225 ft of 2-in. tubing reduces the polished rod load by 13,872 lb over and above the buoyancy affect of the conventional rod string below. This reduction in polished rod load reduces the stress in the sucker rod string to the extent that the lower

TABLE 2.

Rod String Proportions		Weight in Air, lb	Weight in Water, lb	Buoyant Force, lb
42.5% 2" tubing	— 7225 ft	28,900	15,028	13,872
12.8% 1" rods	— 2176 ft	6,260	5,461	799
14.4% ⅞" rods	— 2448 ft	5,390	4,702	688
30.3% ¾" rods	— 5151 ft	8,450	7,372	1,078
100%	17,000 ft	49,000	32,563	16,437

Other data:

Stroke length ..... 240 in.
Pump size ..... 1 1/16-in. diam
Rod stretch (including top run of 2-in. tubing) ..... 63.6 in.
Overtravel ..... 46.1 in.
Net plunger travel = 240 − 63.6 + 46.1 = 222.5 in.
Pumping speed ..... 5.5 spm
Production at 80 percent volumetric eff ..... 130 bpd
Acceleration factor for rod load 1.103
Max polished rod load =
49,100 × (1.103) + (0.886 × 17,000 × 0.4334) − 16,437 = 44,190 lb.
Min polished rod load =
49,000 × (1.000 − 0.103) − 16,437 = ... 27,560 lb
Counterbalance required ..... 35,875 lb
Peak torque on gear reducer ..... 1,173,000 in.-lb
Stress in top 2-in. tubing ..... 33,800 psi
Stress in top 1-in. tubing ..... 37,100 psi

9775 ft can be made up of 1, ⅞, and ¾-in. rods.

The use of tubing in the sucker rod string, in effect, greatly increases the depth from which oil can be produced economically with the use of sucker rods.

Crank Balanced Units

When considering the problems of deep well pumping, the surface equipment that is nearly always selected is either a long stroke air balanced unit or a long stroke crank balanced unit. Which type to select is not always an easy decision to make. The great majority of all wells on artificial lift are pumped by the crank counterbalanced beam type unit (Fig. 1). Advantages of this type unit are:

1. Low first cost,
2. Wide range of application,
3. Simplicity of operation,
4. Low maintenance cost,
5. Long life,
6. High salvage value.

The crank counterbalanced unit is a reliable mechanism universally accepted in the oil industry as being the most simple of all pumping units utilizing a sucker rod string. It was developed many years ago and has been improved steadily. Maintenance costs are low, partly because of the simplicity of the mechanism and partly because of the fact that the personnel of the oil industry are familiar with the operation of these units.

Air Balanced Units

The modern air balanced unit (Fig. 3), compared to the crank balanced unit, is relatively new to the oil fields; however, it has made great strides in the last few years particularly in the field of deep well pumping. The advantages of this type of unit are:

1. These units are 40 percent lighter than comparable crank balanced units.
2. Air balanced units are 30 to 40 percent shorter in overall length than the comparable crank balanced units.
3. Counterbalance can be changed much more easily than is possible on crank balanced units. Counterbalance can be changed by turning a valve without stopping the unit.
4. This type unit can be equipped with an automatic counterbalance control feature.
5. Longer polished rod strokes are available with this type unit than are available in the crank counterbalanced type.
6. This type unit is ideally adapted for pier installations and for installations on substructures.

Although their first cost is slightly more than the crank balanced type units of comparable size, the difference is offset, in many cases, by decreased cost of the foundation and of transportation. Air balanced units have all the advantages of the crank counterbalanced type units; however, there is slightly more maintenance to the air counterbalance system itself as compared to negligible maintenance for the crank weight system. The ease of changing counterbalance, however, will often justify the slight added maintenance.

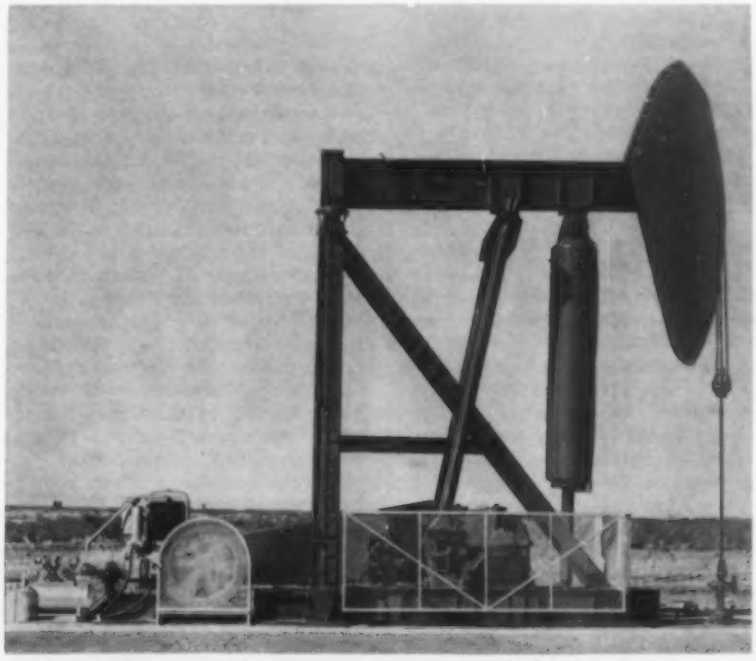

FIG. 3. Air balanced pumping unit has found particular application in the field of deep well pumping. Prime advantage of this type unit is the ease of adjusting counterbalance.

Most wells vary only slightly in the amount of counterbalance required throughout the pumping day; however, any well that has an appreciable variation in counterbalance requirements may quite easily overload the equipment and become a source of considerable expense. For such wells, an automatic counterbalance control is available for air balanced units. The automatic counterbalance control may be used on units with gas engine or electric motor prime movers.

Pumping Unit Selection

We have seen that sucker rod type pumping units can pump oil wells economically and efficiently to depths in excess of 17,000 ft. It can also be definitely stated that in pumping from these depths a long polished rod stroke must be utilized. Whether to use a crank balanced unit with its simplicity of operation or the air balanced type with its longer stroke and automatic counterbalance feature is a problem each operator will have to decide for himself. Each type has its application

---

Fred D. Griffin *was graduated from the University of Texas in 1942 with a bachelor of science degree in mechanical engineering. After serving two years in the navy as an engineering officer aboard an aircraft carrier, he was employed by the Douglas Aircraft Company for three years as a design engineer in their power plant section.*

He has been employed since 1947 by Lufkin Foundry & Machine Company as a design engineer concerned primarily with the development of the company's line of air-balanced pumping units.

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and careful consideration from all angles will often indicate that either type would fill the bill. Seldom will an examination of production figures such as are presented here indicate an obvious unit selection. Other important points such as first cost of equipment, installation costs, operating costs, maintenance costs, salvage value, etc., will have to be considered before a unit selection can be made. Even when these points have been considered fully, two different operators might very easily make different equipment selections when this information is substituted in each company's own "economic formula" which is geared to its own method of operation. ★ ★

The national officers of the Petroleum Section of Special Libraries Association for 1960 are Paul Knapp, chairman (Ohio Oil Company, Littleton, Colorado), Maryann Duggan, vice chairman (Socony Mobil Oil Company, Inc., Dallas, Texas) and Aphrodite Mamoulides, secretary-treasurer (Shell Development Company, Houston, Texas).

SPECIAL LIBRARIES ASSOCIATION FORUM HELD IN DALLAS

THE PETROLEUM SECTION of Special Libraries Association on February 19, held its first national forum on the abstracting and indexing of petroleum exploration and production literature. Trying to keep up with new developments in the field of petroleum exploration and production has grown and is still growing into what seems to be an insurmountable task. The scientific and technical literature that is being published today, if printed on one continuous sheet of paper could probably easily circumscribe the entire globe.

The Petroleum Section of Special Libraries Association, realizing the need for organizing oil production literature, held this forum in an effort to guide the oil industry in taking decisive steps toward a workable solution. The forum was designed to give the oil industry a closer look at the problem and had as its speakers, Paul Knapp, who presented a paper entitled, "Aims of the Forum." Mr. Knapp is chairman of the association and is with the Ohio Oil Company at Littleton, Colorado. Burton W. Adkinson spoke on, "Information: Organized or Lost?" Mr. Adkinson is president of the association and is with the National Science Foundation in Washington, D. C. Other papers were: "Information: The Geologist's Search" by Rhodes W. Fairbridge, Professor of Geology, Columbia University; "Information in Applied Petroleum Research" by Paul P. Reichertz, Socony Mobil Oil Company, Inc., Dallas, Texas; "A Comparison of the Commercial Abstracting Services" by James J. Roark, Jersey Production Research Company, Tulsa, Oklahoma; and "Survey of Abstracting Services in Petroleum Companies" by Maryann Duggan, Socony Mobil Oil Company, Inc., Dallas, Texas.

A dismal, confused future faces all those concerned with abstracting technical literature unless improved standards for abstracting and indexing are developed. There is also a need for a comprehensive abstracting service on a national basis. Working along these same lines is the API Study Team on Abstracting Exploration and Production Literature. This committee, made up of representatives from both oil and service companies, was appointed by the API Advisory Committee on the Fundamental Research on the Occurrence and Recovery of Petroleum (ACFRORP) to study the type of abstracting and indexing service needed, and draw up standards and specifications for such a service.

In the discussion section which followed the forum, it was decided that the API Study Team be asked to cooperate with the Petroleum Section of Special Libraries Association on this project. As a result of this forum the API Study Team and the Petroleum Section of SLA are now in the process of (1) setting up standards for a good abstracting and indexing service which would abstract exploration and production articles from some 600 journals and patent gazettes (roughly 10,000 abstracts a year), (2) looking into the proposals from several firms and institutions which are willing to offer such a service, and (3) polling the oil industry to find out its needs and what it would be willing to pay for such a service.

In the next few months the oil industry can look forward to receiving a summation of the standards set up by the Study Team and a review of the proposals which have been made by various firms and institutions to offer the industry an abstracting and indexing service. ★ ★ ★

How to determine . . .

Dynamic Loads in Sucker Rods

The lumped-parameter method of analysis provides a convenient means of determining the load characteristics of sucker rods

Joseph R. Norton, *Oklahoma State University, Stillwater, Oklahoma*

OVER THE YEARS considerable effort has been devoted toward a better understanding of the nature of sucker-rod pumping. This problem was investigated by Coberly,[1] Mills,[2] Kemler,[3] Slonneger,[4] and others during the 30's and 40's. Since World War II the trend has been to extend the lumped-parameter analytical approach by considering the rods, fluid, and tubing as continuous or distributed systems. This approach under the direction of Howe[5] and Kemler has led to a set of equations considered to be beyond analytical solution. These investigators, together with Halderson,[6] have been instrumental in the present impetus toward simulation and analog solutions.

In the lumped-parameter method of analysis the entire mass of the element is assumed to be concentrated at a point, and the elastic effects are assumed to be in a massless spring connecting the mass and the driving element. The continuous or distributed method of analysis assumes the mass and elasticity to be uniformly distributed throughout the element.

It is generally recognized that a complete analysis must consider the surface equipment, the rod string, fluid column, tubing, and bottom-hole pump. To make an analysis which would consider all these elements requires that the nature of the various elements must be known or characterized. An objective of this report is to determine the characteristics of the rods. Another objective is to determine the relative importance of other well elements in contributing to the load on the rods. Realization of these objectives would, of course, be only another step toward a more complete analysis where consideration would be given to the surface equipment as well as subsurface equipment. It should be noted, however, that the rods are the most significant of the well elements in determining the nature of the overall system.

Assumptions and Methods of Approach

An analytical approach to a real problem, such as the analog or simulator approach, requires simplification of the system. A basic assumption in this report is that the prime mover has sufficient power to force upon the polished rod a prescribed motion throughout the pumping cycle. That is to say the in-put displacement, as a function of time, is established by the prime mover and the geometry of the unit. If the polished rod is driven by a sinusoidal velocity function of constant amplitude operating into a system of rods, fluid, tubing, and pump, the resulting polished-rod load will depend upon the nature of these various elements. Based on this premise a given set of surface equipment, operating under fixed conditions, will reflect any change in subsurface equipment or conditions as a change in the dynamic polished-rod load. For the purpose of analysis a sinusoidal varying velocity will be used. This is particularly convenient in that it makes for a simplified solution and, at the same time, allows for the analysis of any periodic velocity wave form by means of Fourier analysis.

A lumped-system analysis was made to evaluate the relative significance of the various well elements in determining the dynamic rod loads. It should be noted that analysis by this method gives information relative to the load or velocity of the element only at the ends of the assumed massless spring. This may appear to be a rather restrictive analysis. However, for normally encountered pumping speeds and well conditions, this approach does yield usable results as is evidenced by the success of the Mills and Slonneger formulas which are of this nature.

The lumped-system analysis approach has led to the following conclusions regarding the various well elements. As a lumped system the tubing string, for normal well conditions, is approximately four times as stiff as the rods and its mass is also about four times the mass of the rods. Considering that the rods are connected to the tubing only by the friction in the pump (and as they slide along the tubing), it is evident that the large mass of the tubing is relatively unaffected by the weak spring of the sucker rods. Although the movement of the tubing is not negligible, the effect of this movement can only be transferred to the rods by a relatively weak frictional coupling. The tubing displacement, therefore, has little effect on the sucker-rod load and can be ignored. Analysis of net displacements, however, cannot be made in this manner. As a result of the lumped analysis, the tubing string was excluded as a well element influencing the dynamic sucker-rod load. Since this analysis was made, those active in the simulator and analog experiments have arrived at much the same conclusion.

From the lumped-system analysis some information was obtained regarding the transient loads caused by the action of the valves in the pump. It was found that the transient load may approach the magnitude of the maximum dynamic load during the pumping cycle. For normal pumping conditions, however, the transient load occurs early in the cycle, prior to the maximum steady-state load, and hence

Presented by the author at the Spring Meeting of the Southwestern District, Division of Production, American Petroleum Institute, Dallas, Texas, March 2-4, 1960.

is not additive to the steady-state load because of the phasing present.

With respect to the fluid column, it was found that even though its mass is roughly equivalent to that of the rods, as a spring the fluid column is only 1/20 as strong as the rods and 1/80 as strong as the tubing. Considering the weakness of the fluid as a spring, together with the fact that the fluid load is transferred to the rods through a transformation ratio equal to the ratio of the net area of pump to net area of tubing, it is evident that very little dynamic load from the fluid is imposed upon the rod string. Bottomhole dynagraph cards record practically a straight maximum load line verifying the foregoing statement. If the fluid, whose natural frequency is approximately ¼ that of the rods, was instrumental in contributing to the dynamic rod load, the pump cards would present a wavy maximum load line. Some waviness can be observed; however, its magnitude is in general on the order of one percent of the maximum load and hence does not contribute significantly to the dynamic load in the rods. The fluid load will then be considered as a lumped load for the purposes of determining the nature of the rod string.

In the lumped fluid system, viscosity can be included in the analysis. It has been found, for example, that wells of 3000 to 10,000 ft have a frictional load between the fluid and rod elements of 8 to 12 lb per 1000 ft. The corresponding frictional force between the fluid and the tubing is between 75 and 450 lb. It is assumed then that the frictional load between rods and fluid can be ignored and the frictional load between fluid and tubing can be lumped at the pump.

The rod line will be investigated as a distributed system or element, in order that information may be had relative to the distribution of the loads and velocities throughout the length of the rod string. Knowing the load throughout the length of the rods will aid in proportioning stepped strings based upon the combined static and dynamic loads.

This latter point will become increasingly important as wells become deeper, since the dynamic load between the rod ends at times exceeds the dynamic load at the polished rod. The dynamic load reversal together with the static load of the fluid determines the range of load in the rods. It is possible then to have greater ranges of stress at some point along the rod string than exist at the polished rod, hence a potential failure section may exist because of the repeated load nature of the pumping operation.

A final assumption is that all static and coulomb friction loads can be ignored in the computation of the dynamic loads. This is to say that although the static weight of the rods contributes to its static load, it does not contribute to the dynamic load. This is not actually an assumption since the weight is invariant with time, therefore its derivative with respect to time is zero and does not appear in the dynamic equations.

Derivation and Solution of Distributed Equations

An incremental element of the rod, of Δx length, is chosen at an arbitrary distance, x, from the pump as shown in Fig. 1. The rod is assumed to be made up of elements uniform in size and density and to have uniform frictional losses along its surface. In general, the instantaneous force, f, and velocity, v, depend upon two independent variables — time and position — and must be expressed as partial differentials in the equations of motion.

Let u be the displacement of the element caused by the motion. Velocity of the element will be defined at any time as:

$$v = \frac{\delta u}{\delta t} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad a$$

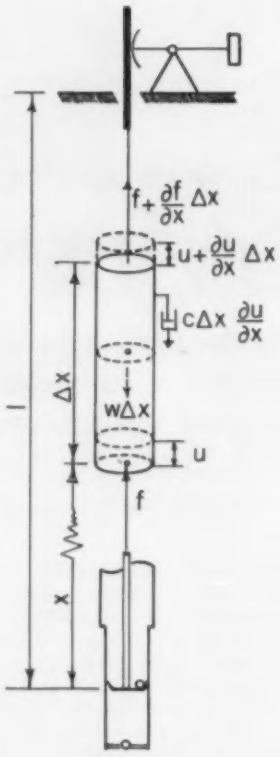

FIG. 1. Distributed well model shows the various subsurface components as considered in the lumped-parameter method of sucker rod load analysis.

Within the proportional elastic limit of the rod material, Hooks' law states that the ratio of the unit stress to the unit strain is a constant or:

$$E = \frac{f\Delta x}{A_r \varepsilon \Delta x} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad b$$

Wherein E is, by definition, Young's modulus of elasticity and ε is the unit strain.

Referring to the element in Fig. 1, the strain can be expressed as:

$$\varepsilon \Delta x = u + \frac{\delta u}{\delta x} \Delta x - u = \frac{\delta u}{\delta x} \Delta x \quad . \quad . \quad . \quad c$$

Solving Equation b explicitly for the instantaneous load results in:

$$f\Delta x = AE\varepsilon\Delta x \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad d$$

Eliminating $\varepsilon\Delta x$ from Equations c and d gives:

$$f = AE \frac{\delta u}{\delta x} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad e$$

Now taking the derivative of this expression with respect to time gives:

$$\frac{\delta f}{\delta t} = AE \frac{\delta^2 u}{\delta x \delta t}$$

but $$\frac{\delta u}{\delta t} = v$$

hence $$\frac{\delta v}{\delta x} = \frac{1}{AE} \frac{\delta f}{\delta t} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 1$$

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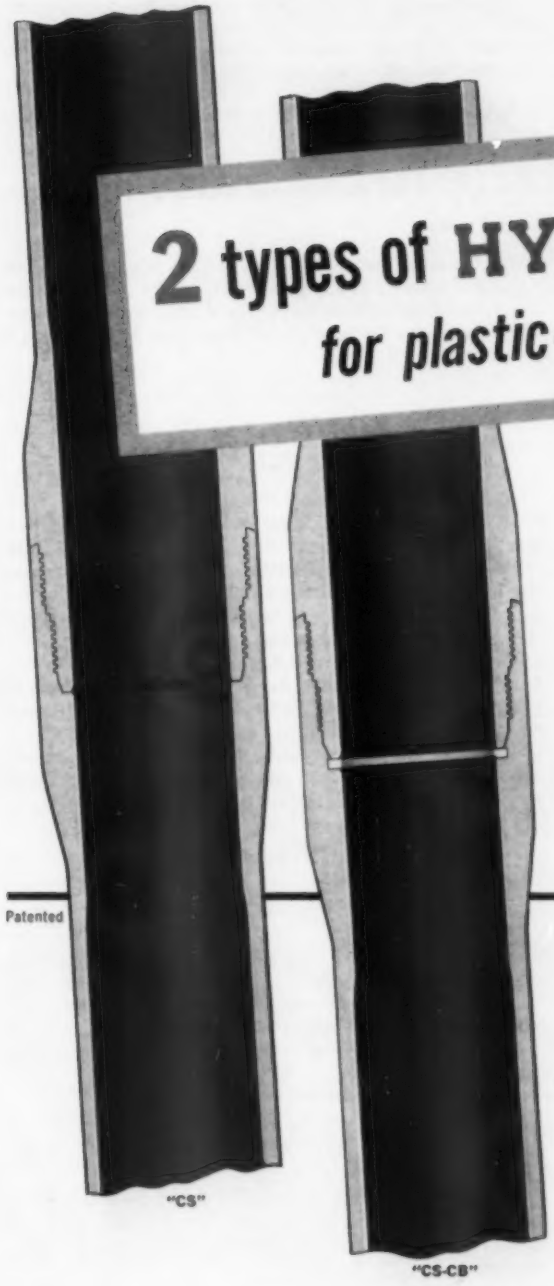

In corrosive wells . . . or to resist costly paraffin buildup . . . operators are turning more and more to plastic coating the I.D. of tubing. The joint is the critical spot in this operation: if coating flows over the *end* of the pin, it will hold off a tight-sealing makeup; if coating stops short of the end of the pin, the critical sealing point is left unprotected.

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Equation 1 shows the dependence of the force and velocity upon time and position. Newton's second law or D'Alembert's principle furnish another relationship by equating the unbalanced forces acting on the element to the product of mass and acceleration. This equation, based on Fig. 1, is

$$\frac{\delta f}{\delta x}\Delta x - c\Delta x\frac{\delta u}{\delta t} = \frac{w}{g}\Delta x\frac{\delta^2 u}{\delta t^2} \quad . \quad . \quad . \quad . \quad f$$

Recalling that $\frac{\delta u}{\delta t} = v$, Equation f can be rewritten as:

$$\frac{\delta f}{\delta x} = cv + \frac{w}{g}\frac{\delta v}{\delta t} \quad . \quad . \quad . \quad . \quad . \quad . \quad 2$$

By definition, the spring constant, k, for a uniform rod section is AE/1. Let Δx be a unit length (1 ft) of rod line and define M as the mass of the element. Equations 1 and 2 can then be written as:

$$\frac{\delta v}{\delta x} = \frac{1}{k}\frac{\delta f}{\delta t} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 3$$

and

$$\frac{\delta f}{\delta x} = cv + M\frac{\delta v}{\delta t} \quad . \quad . \quad . \quad . \quad . \quad . \quad 4$$

Equations 3 and 4 are the basic equations of motion for the element. As stated earlier, a sinusoidal driving function will be used in the solution of these equations from which the amplitude or magnitude of the force and velocity can be determined. A more convenient form of the equations can be obtained by expressing the instantaneous values of force and velocity as two components, a magnitude (dependent on position only) and an operator (dependent on time only) as follows:

$$f = Fe^{i\omega t}$$

$$v = Ve^{i\omega t}$$

The time operator $e^{i\omega t} = \mathrm{Cos}\omega t + i\,\mathrm{Sin}\omega t$. It can represent either a cosine or sine driving function, depending on the component (real or imaginary) used. Furthermore, the pumping speed is represented by ωt; therefore, the foregoing equations fulfill the requirements of a sinusoidal driving function for the steady state.

Taking the derivative of the last two expressions with respect to time and substituting into Equations 3 and 4 gives:

$$\frac{dV}{dx} = \frac{i\omega}{k}F \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad g$$

and

$$\frac{dF}{dx} = (c + i\omega M)\,V \quad . \quad . \quad . \quad . \quad . \quad h$$

Equations g and h by action of the time operator have now become ordinary differential equations since they are functions of a single independent variable, x. Differentiation of Equations g and h with respect to x gives:

$$\frac{d^2F}{dx^2} = zyF \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 5$$

and

$$\frac{d^2V}{dx^2} = zyV \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 6$$

wherein $z = c + i\omega M$ and $y = i\omega/k$.

Equations 5 and 6 can be interpreted as wave equations and their solutions can be expected to be interpreted in terms of traveling waves. In terms of traveling waves, the following quantities are defined as:

$\gamma = \sqrt{zy}$ = the propagation constant for the element or rod section, and

$Z_c = \sqrt{\frac{z}{y}}$ = the characteristic impedance of the element or rod section.

Using the notation that F and V are the magnitudes of the force and velocity at any position, x, let the unknown force and velocity at the pump be F_p and V_p. Applying these boundary conditions the solution of Equations 5 and 6 can be written as:

$$F = F_p\,\mathrm{Cosh}\,\gamma x + Z_c V_p\,\mathrm{Sinh}\gamma x \quad . \quad . \quad . \quad . \quad i$$

$$V = \frac{F_p}{Z_c}\,\mathrm{Sinh}\gamma x + V_p\,\mathrm{Cosh}\gamma x \quad . \quad . \quad . \quad . \quad j$$

In these equations F and V are dependent upon the position, x; e.g., F becomes the dynamic polished-rod load when $x = l$. Equations i and j can be used to calculate the load and velocity distribution along the rod string provided F_p, V_p, Z_c, and γ can be evaluated. The latter two of these parameters are dependent upon the physical properties and size of the rods, hence they can be calculated. Expressions for F_p and V_p must be developed. These items will be examined separately, with special attention given to simplification.

Characteristic impedance, Z_c, as the name implies, denotes a reluctance of a particular rod element to move. A number can be assigned to this impedance as follows:

$$Z_c = \sqrt{\frac{z}{y}} = \sqrt{\frac{c + i\omega M}{\frac{i\omega}{k}}} = \sqrt{kM - i\frac{ck}{\omega}} \quad . \quad . \quad k$$

When the value of k runs to the thousands and M to the hundreds, it is easy to see that the imaginary quantity, ck/ω can be ignored since it is in general on the order of 1/10 the product of kM. Under these conditions, Z_c is invariant for a uniform section of rod, hence it can be calculated for future reference:

Rod size, in. —	½	⅝	¾	⅞	1
Z_c —	372	575	820	1110	1450

It should be noted that the units of Z_c are force divided by velocity, or F/V. It is this property which makes Equations i and j homogeneous since hyperbolic functions are dimensionless.

Examination of the propagation constant can be made by expressing it in complex form, as:

$$\gamma = \alpha + i\beta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 1$$

wherein α = the attenuation constant, and β = the phase constant.

The attenuation constant α determines the manner in which the force or velocity is reduced as it travels along the rod string. This quantity then depends upon the internal frictional losses and has been found to be negligible in steel rods at ordinary pumping frequencies. The phase constant β is a measure of the time required for a force or velocity initiated at one point to reach another point along the rod

Skinner Brothers' Report No. 1

New Product Gains Industry Acceptance

Hydraulic oil saver sales ascend even during period of lagging oil field equipment purchasing

NEW PRODUCT development in the oil field equipment industry is often characterized by frustration.

The problem is hardly ever one of failing to accomplish the desired advance. It is more often one of not knowing when to stop designing and start producing.

New designs to meet functional requirements usually end in complicated equipment.

The ideally-designed equipment will perform its function with simplicity which means safe and economical operation.

Meeting the Ideal. That ideal has been met in the development of a new hydraulically operated oil saver by the Skinner Brothers Company.

This equipment is one of the most advanced of its kind on the market.

Sales to date have clearly indicated quick acceptance of the product on the part of equipment buyers.

The Skinner Brothers hydraulic oil saver was first introduced in December 1959. In the early part of 1960, sales of this equipment rose strikingly even though industry-wide equipment sales were on a distinct downward trend.

Hydraulic operation of oil savers was recognized some time ago as a necessity in the oil patch — particularly from the viewpoint of safety.

Solving the Problems. Skinner Brothers' research and development department set out to develop a hydraulic oil saver which would solve every major problem accompanying oil savers and their use.

These problems included:

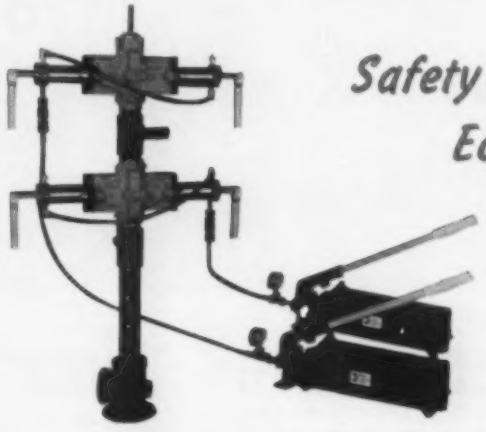
(1) The necessity of shutting down operations if hydraulic pressure failed, and

(2) The absence of any means of measuring packing rubber wear to prevent wear-out in the middle of operations.

The result of this approach was the development of a piece of equipment which provided, first, instant means for operation by hand in the event of hydraulic failure, and, second, a quick and easy method of gauging packing rubber wear at all times.

Both of these capabilities contributed significant improvement in ease of operation and economy, without detracting from the prime function of the hydraulic oil saver — the safer performance of the wire stripping function.

Details of design in the Skinner Brothers hydraulic oil saver have been published in booklet form and are available on request to P. O. Box 628, Tulsa, Okla.



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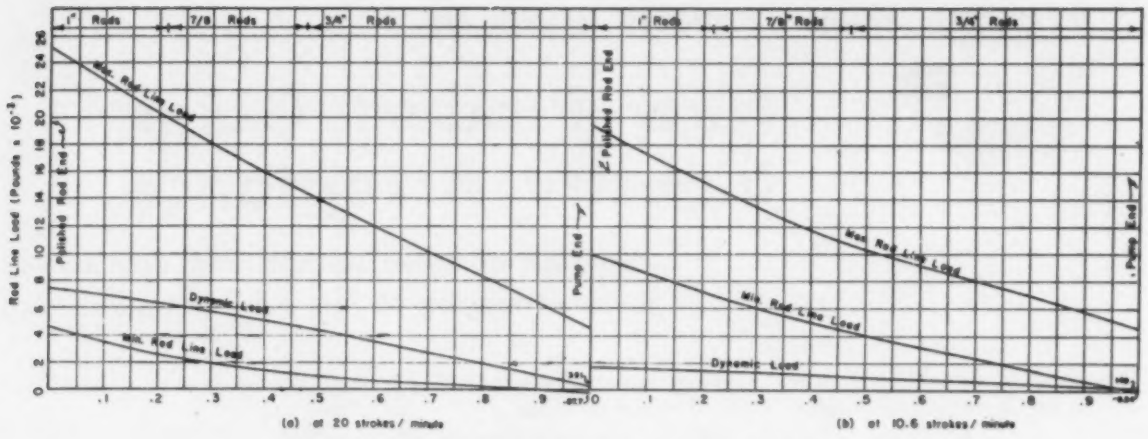


FIG. 2. Well profiles at 20 strokes per min and 10.6 strokes per min illustrates the rod line loads throughout the length of the line.

string. Two useful relationships can be determined from these considerations.

a. $\beta = \frac{\omega}{a}$ where a is the velocity of sound in the material and ω is the frequency of the driving function.

b. $\lambda = \frac{2\pi}{\beta}$ where λ is the wave length of the transmitted or reflected wave.

Since $\alpha = 0$, γ can be replaced by $i\beta$ and the hyperbolic functions of purely imaginary arguments are reduced to an ordinary trigonometric function. Hence Equations i and j become:

$$F = F_p \cos\beta x + iZ_c V_p \sin\beta x \quad . \quad . \quad . \quad . \quad 7$$

$$V = i\frac{F_p}{Z_c} \sin\beta x + V_p \cos\beta x \quad . \quad . \quad . \quad . \quad 8$$

Means are now available for calculating Z_c and β, and it remains to obtain expressions for F_p and V_p.

Starting with the work of W. E. Gilbert[7] and combining these results with the lumped-parameter approach, F_p can be approximated by:

$$F_p = V_p n^2 [3l_v L(\text{sp.gr.}) + i\omega M_f] \quad . \quad . \quad . \quad 9$$

wherein

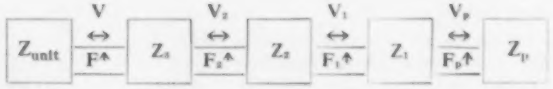
n = the ratio of the net pump area to the net tubing area
υ = kinematic viscosity of the fluid
L = length of fluid column
M_f = mass of fluid in the tubing

It is admitted that Equation 9 may be refined; in fact, this could become the subject of a theoretical and experimental investigation. As it stands, however, it shows good agreement with available data.

Acceptable engineering accuracy can be obtained for the velocity at the pump by assuming F_p to be zero and solving Equation 8 for V_p giving:

$$V_p = \frac{V\ (\text{pol. rod})}{\cos\beta l} \quad . \quad . \quad . \quad . \quad . \quad 10$$

Equations 7 through 10 contain all the necessary information to determine the dynamic load and velocity at any position along the rod string for a uniform or single-size rod. Determination of the loads and velocities at the rod junction for tapered strings can be facilitated by use of the following block diagram.



$$F_t = F_p \cos\beta x_t + iZ_t V_p \sin\beta x_t \quad . \quad . \quad . \quad 11$$

$$V_t = i\frac{F_p}{Z_t} \sin\beta x_t + V_p \cos\beta x_t \quad . \quad . \quad . \quad 12$$

$$F_s = F_t \cos\beta x_s + i Z_s V_t \sin\beta x_s \quad . \quad . \quad . \quad 13$$

$$V_s = i\frac{F_t}{Z_s} \sin\beta x_s + V_t \cos\beta x_s \quad . \quad . \quad . \quad 14$$

$$PRL = F = F_s \cos\beta x_s + i Z_s V_s \sin\beta x_s \quad . \quad . \quad 15$$

$$PRV = V = i\frac{F_s}{Z_s} \sin\beta x_s + V_s \cos\beta x_s \quad . \quad . \quad 16$$

Use of the foregoing equations requires that certain well parameters be calculated from known well conditions. A complete example of dynamic-load calculation by this method is given in Appendix A. This calculation gives the maximum rod load during the upstroke.

The range of load can be determined by calculating the maximum load during the downstroke. To calculate the downstroke load, the expressions for the pump load will require modification. Equation 17 can be utilized for this purpose.

$$F_{pd} = \left(\frac{V_p d_p}{2}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad 17$$

wherein d_p is the diameter of the pump, in inches. This equation is applicable only when the balls and seats meet API specifications. Pumps having larger or smaller balls and seats will require a modification of the foregoing equation.

Presentation of Results

Having developed the necessary relationships to calculate the dynamic loads and velocities throughout the rod string, a program was developed for the IBM 650 computer to calculate these loads for both the upstroke and downstroke. In the computer program the static and coulomb friction loads were computed and added to the dynamic loads. From this program considerable information about the behavior

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of the pumping system has been obtained. Fig. 2, for example, gives the well profiles determined from the computer program for the same well as used as the example in Appendix A. Fig. 3 presents the variation in polished-rod load as a function of the pumping speed, with separate curves for the analytical data and the actual measured data. To date some 33 wells have been analyzed by the computer program. Results of these analyses are presented in Fig. 4. It should be noted that the program was formulated to produce in general a greater maximum load and smaller minimum load than is measured. This results in a small but significant built-in safety factor.

Conclusions

The ultimate polished-rod load is a function of many well parameters, some of which are explicit in the dynamic equations and others are only implied. These parameters include:

a.	Pumping speed	SPM
b.	Length of stroke	L
c.	Pump size	d_p
d.	Viscosity of fluid	ν
e.	Net lift	L′
f.	Specific gravity	ρ

It is then evident that more information must be known about a well to use the distributed rod-string equation than is required to use the ordinary lumped formula. With the computer to perform the calculations by obtaining or assuming the required information, one parameter can be varied as the others are held fixed. This has been done for some wells and a few variables and the following generalized conclusions, which are in agreement with known field practice, can be made:

a. Effect of varying the pumping speed.
In general the polished-rod load increases exponentially with increasing speed.

b. Effect of varying length of stroke.
In general the polished-rod load increases with increasing stroke length, but it does so as a straight-line function and at a lesser rate than by increasing the speed to obtain equivalent production.

c. Effect of varying viscosity.
Low-viscosity fluids have little effect on the polished-rod loads. However, as the viscosity approaches 10^{-2}, the polished-rod load increases very rapidly.

d. Effect of varying the net lift.
In general the dynamic and total polished-rod loads increase slightly with net lift. Since the polished-rod load is proportional to the length of the rod string, any reduction in pumping depth is most desirable.

e. Effect of friction and specific gravity.
Friction primarily influences the static load and hence is detrimental to economical operations. Specific gravity primarily influences the dynamic load and hence the range of load.

Two additional observations should be noted. First, it is significant that the general power requirements of a pumping system, and hence the economy of operation, depend upon the unbalanced static weight and the coulomb friction in the system. Therefore the designer should strive to minimize these two factors at all times. Second, the rod string has a characteristic impedance with a very large real component and a smaller negative reactive component. To effect an impedance match at the pump and unit requires that these

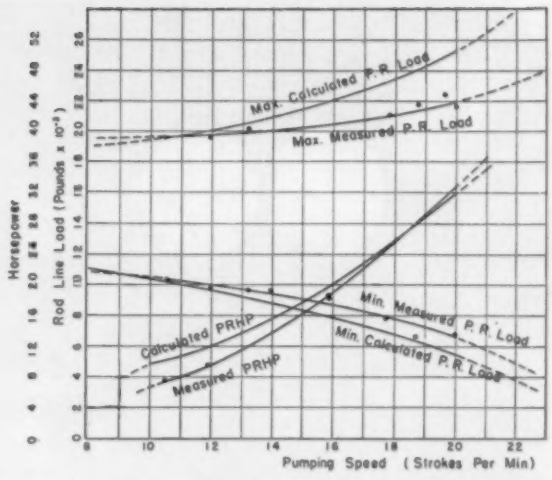

FIG. 3. Variation in polished-rod load as a function of pumping speed is shown with separate curves for analytical data and actual measured data.

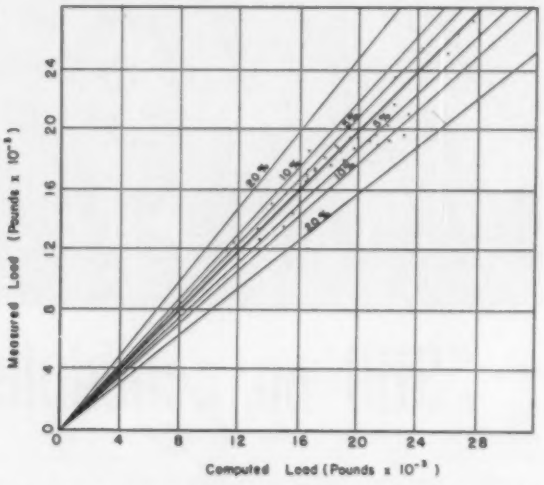

FIG. 4. Computed loads are compared with measured loads in the analysis of 33 wells.

elements have an impedance with a positive reactive component. The pump impedance Z_p, obtained by dividing F_p by V_p, shows that the pump has a small positive reactive component. The direct way of producing an impedance match at the pump is to increase the product of ωM_r. Since increasing this product requires that either the pump speed or pump size must be increased, the dynamic polished-rod load will increase as the impedances are matched. The analysis and interpretation of the consequences of impedance matching would be a worthwhile problem for further study. On the unit end of the rods, no analysis has been made. However, the nature of the units indicates again the presence of a positive reactive component. It may be that under certain conditions a corrective element in the form of additional elasticity or slip in the system will be required to accomplish an impedance match.

In conclusion it is hoped that this work may eventually be carried forward to the point where an overall system analysis may be made. When this is done, design criteria can be established for surface equipment and bottom-hole pumps.

Acknowledgment

Acknowledgment is made of the sponsorship of W. C. Norris Manufacturer, Division of Dover Corporation, Tulsa, Oklahoma, without which the work from which this report has resulted could not have been accomplished.

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APPENDIX A

Sample calculation for a 6500 ft, 3-way taper rod string.
Well data:
Total depth — 6549 ft
Production — 48 bbl oil, 315 bbl water
Working fluid level — assumed 6542 ft
Tubing size — 2½ in.
Rods — 1450 ft — 1 in.
1700 ft — ⅞ in.
3392 ft — ¾ in.
Pump — 1½ in., type unknown
Pumping speed — 20 strokes per min
Length of stroke — 74 in.
Type of unit — beam
Pump depth — 6542 ft
Specific gravity of fluid — 1.154

Calculated parameters from well data:

$$\text{Mass of fluid in tubing } M_f = \frac{W_o}{32.2} = 412 \text{ slugs}$$

$$\text{Angular frequency} = \frac{SPM}{9.55} = 2.094 \text{ radians per sec}$$

$$\text{Velocity of polished rod } V = \frac{SPM \times \text{length of stroke in ft}}{19}$$

$$= 6.492 \text{ ft per sec}$$

$$\text{Transformation ratio } n = \frac{\text{net area pump}}{\text{net area tubing}} = 0.294$$

$$n^2 = 0.0864$$

$$\text{Phase constant } \beta l = \frac{SPM \times \text{length of rods in ft}}{162{,}000}$$

$$= 0.808 \text{ radians}$$

$$0.808 \text{ radians} = 46.275 \text{ deg}$$

$$\text{Cos } 46.275 \text{ deg} = 0.691$$

$$\text{Velocity of pump} = V_p = \frac{V}{0.691} = 9.4 \text{ ft per sec}$$

Impedance —

Lower rod section — $Z_3 = 820$ lb-sec per ft
Center rod section — $Z_2 = 1110$ lb-sec per ft
Upper rod section — $Z_1 = 1450$ lb-sec per ft

Phase constant of lower rod sections —

$$\beta l_3 = \frac{\omega l_3}{a} = \frac{2.094 \times 3392}{16{,}800} = 0.423 \text{ radians per sec}$$

$$\text{Sin } \beta l_3 = 0.411$$

$$\text{Cos } \beta l_3 = 0.912$$

Phase constant for center rod section —

$$\beta l_2 = \frac{\omega l_2}{a} = \frac{2.094 \times 1700}{16{,}800} = 0.212 \text{ radians per sec}$$

$$\text{Sin } \beta l_2 = 0.210$$

$$\text{Cos } \beta l_2 = 0.978$$

Phase constant for upper rod section —

$$\beta l_1 = \frac{\omega l_1}{a} = \frac{2.094 \times 1450}{16{,}800} = 0.176 \text{ radians per sec}$$

$$\text{Sin } \beta l_1 = 0.175$$

$$\text{Cos } \beta l_1 = 0.985$$

Lumped fluid load on pump —

$$F = V_p n^2 [31_v L_\rho + i_\omega M_f]$$

$$= 9.4(0.0864)\,[31 \times 1.2 \times 10^{-3} \times 6542 \times 1.154 + i\,2.094 \times 421]$$

$$= 228.5 + i\,700.7$$

Load at top of lower rod section —

$$F_3 = (228.5 + i\,700.7)\,0.912 + i\,9.4 \times 820 \times 0.411$$
$$= 208.4 + i\,3807$$

$$V_3 = i\frac{(228.5 + i\,700.7)}{820} \times 0.411 + 9.4 \times 0.912$$

$$= 8.22 + i\,0.115$$

Load at top of center rod section —

$$F_2 = (208.4 + i\,3807)\ 0.978 + i(8.22 + i\,0.115) \times 1110 \times 0.210$$

$$= 177 + i\,5639$$

$$V_2 = i\frac{(208.4 + i\,3807)}{1110} \times 0.210 + (8.22 + i\,0.115)\,0.978$$

$$= 7.32 + i\,0.152$$

Load at polished rod —

$$PRL = F = (177 + i\,5639)\,0.985 + i(7.32 + i\,0.152)\,1450 \times 0.175$$

$$= 135.78 + i\,7412 = \underline{7413/88.95 \text{ deg}} \text{ with reference to input velocity}$$

$$VPR = V = i\frac{(177 + i\,5639)}{1450}\,0.175 + (7.32 + i\,0.152)\,0.985$$

$$= 6.53 + i\,0.179$$

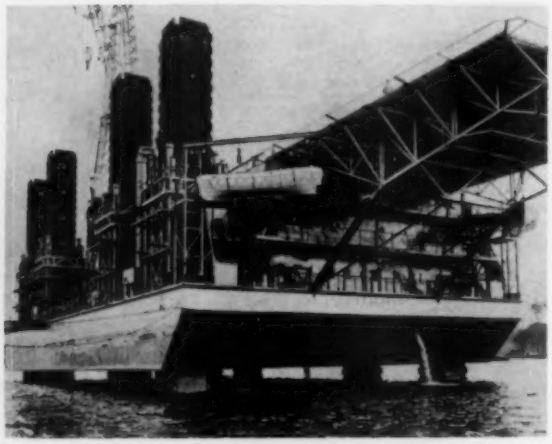
$$= 6.531\ \underline{/1.5 \text{ deg}} \text{ checks with 6.492 original velocity}$$

* * *

Shell Christens TWO New Drilling Platforms

TWO MOBILE DRILLING PLATFORMS have recently been added to the offshore fleet of Shell International Petroleum Company Ltd., ready to expand Shell's world-wide search for under-sea oil.

The Seashell



The $5,000,000 "Seashell" was built for Shell as a more versatile successor to the platform wrecked in a sudden storm three years ago off Qatar, in the Persian Gulf, and was commissioned in Doha Bay, Qatar. His Highness Sheikh Ali bin Abdulla Al Thani, ruler of Qatar, cut a tape to start the drilling machinery after both the Qatari and Shell flags had been hoisted.

Two Dutch tugs towed the "Seashell" 6400 miles to Doha Bay from Schiedam, Holland, where it was built. The trip took 75 days at an average speed of 3½ knots. Mostly the weather was good and the tugs could do four to five knots. But a head-on gale in the Red Sea cut this to one knot for a day or two and even halted progress altogether for a while. Apart from this, the voyage was uneventful.

During the journey, five men from the towing contractor were on board the 5930-ton vessel, plus two Shell engineers whose job was to maintain the platform machinery.

The "Seashell" consists of a pontoon 209 ft long, 105 ft wide, and 17 ft deep, with eight legs 218 ft long and 10 ft square. It has been designed to withstand gales of up to 100 miles an hour and waves 30 ft high, while working in water 100 ft deep. The pontoon hull carries drilling machinery suitable for drilling to depths of 17,000 ft, and auxiliary servicing equipment including a 75-ton mobile crane. The platform has a detachable helicopter deck which projects over the water and can be folded away before making long tows.

Before the storm wrecked the first platform, the rig had drilled two exploratory wells in Shell's marine concession off the shores of Qatar, the second being about 50 miles off the coast. Results were disappointing, but Shell — which by that time had spent over $20,000,000 on underwater exploration in the area — decided to try again at another location also about 50 miles off the coast.

The "Seashell" will be towed out to this new drilling site. Its eight legs will be lowered to the seabed and the pontoon hull raised 30 ft above water level. With the platform secure, drilling operations will start on the new well. The target depth is around 7000 ft.

The "Seashell" has accommodations for about 70 — including staff, drilling crew, and service personnel. The majority will stay aboard for 8-day spells, followed by four days ashore.

The Triton

Shell's second mobile drilling platform was built by Clelands Shipbuilding Company. Called the "Triton," she was designed by Shell's Dutch associates, Bataafse Internationale Petroleum Mij., in conjunction with DeLong Ltd. who, as main contractors, have been responsible for engineering and supervision of construction.

The "Triton," which cost over $1,500,000 and contains 1500 tons of steel, was built for operations in water depths up to 120 ft and is fitted with four retractable legs, each 200 ft in length and 8 ft in diameter. For reasons of stability, only an 80-ft length of each leg is installed for tow. The remaining lengths, together with 16-ft diameter footings, designed to limit soil penetration, will be lashed to the deck during tow. Construction, including installation of the main drilling equipment, will be completed on arrival.

At the operational site, the hydraulic mechanism will be used to raise the entire platform, at a speed of 30 ft per hour, clear of the water and any lifting action of waves. As drilling is finished, the legs will be raised and the platform towed to another location. Living accommodations on board have not been provided for, as drilling crews will be ferried to and from shore bases.

The "Triton" is designed to withstand waves of 8 ft in height from trough to crest and a wind velocity of 75 mph under operating conditions.

Hydraulic cylinders for raising and lowering the legs are powered by pumps driven through 60-hp electric motors drawing current from four alternators each of 136-kw rating.

The platform is 115 ft long, 80 ft wide, and 15 ft deep.

★ ★ ★

Small Rods Mean Big Savings

Wider use of the new ½ in. size sucker rod is effecting important savings for many cost-minded operators. This article tells you when to use this rod and how it will save money on other components of the pumping installation as well as on the direct cost of the rods

Jack D. Gale, *Liberty Manufacturing Company, Fort Worth, Texas*

THE HALF-INCH ROD is a relative newcomer to the 100 year-old oil industry and, like all newcomers to established communities, it has not been accepted with open arms. However, the half-inch rod does have a very definite place in the petroleum "society." This place is generally for lower volume, shallower, marginal wells and/or multiple completions. Its principal advantage is economy; in addition, it frequently results in better-balanced wells.

Some Resist Any Changes

I know a man who, although he lives alone, still maintains a 12-room house. I've suggested to him, "Why don't you buy a smaller house, or rent a small apartment? The upkeep of this place must be eating you alive." But my friend always says, "I've lived here all my life and I'm comfortable here. I don't want to change." And he's not really concerned about the upkeep, since he can afford it.

There are some disturbing similarities between my friend and the present state of the oil business. We have grown into many practices that we still follow out of habit, though we've forgotten the original reasons for such practices. They are comfortable, and we don't like to change. But the analogy fails at one point: Unlike my friend, the oil industry cannot afford the luxury of maintaining the status quo indefinitely.

Oil men today are tossed on the proverbial "horns" of a dilemma . . . caught between accelerating costs on the one hand . . . discouragingly diminished returns on the other. This financial dilemma is, fortunately for the industry, forcing some of us out of our "ivory tower thinking." As is so frequently pointed out, production, material and labor costs are all rapidly rising, without a compensating increase in price of crude or in production allowables.

What we need is some method to objectively analyze the economic prospects of the oil industry. Since there is no known way of peeking into the future, we can only attempt an intelligent prognosis on the basis of the information available to us. This information indicates that for the next few years, barring a radical technological breakthrough:

Exploration costs will continue to rise . . . fewer and smaller domestic oil reserves will be found. Dry hole ratios will increase.

Drilling costs will continue to rise . . . creeping inflation will push up labor, equipment, and service costs.

Completion costs will continue to rise . . . here the sad plight of domestic oil is brought sharply into focus. The high lifting costs of "marginal" United States wells (often $2 per bbl) can not compete with North African fields where lifting costs are measured in tenths of a cent per barrel.

Added to this grim picture is the possibility, not to be dismissed, of further cuts in revenue brought about by a reduction of the depletion allowance or further cuts in allowables.

Classically, a dilemma has no resolution. What resolution is there for the oil industry's dilemma? A glance at today's world oil production and consumption convinces us that it is wishful thinking to expect relief in the price of crude in the near future. Nor can we expect significant increases in allowables. Our only alternative is to attack rising costs through improved technology.

Cost Cutting Methods Must Be Applied

Forward-looking, cost-conscious managements have been facing the hard realities squarely. Recognizing the need to cut costs, in order to reduce mounting capital investment and speed up lagging payouts, they have turned to wells of smaller diameter to reduce tonnage of steel. Each reduction . . . from 8⅝ in. to 7 in . . . from 7 in. to 5½ in., has resulted in substantial savings in equipment and steel costs. Now, the use of 4½ in. OD and, more recently, 2⅞ in. OD tubing as casing has been made a practical reality by the development of satisfactory ½ in. sucker rods.

Although unheard of four years ago, complete equipment and services are now available for the 2⅞ in. slim hole, which represents today's ultimate in economical wells.

Since 90 percent of all the wells presently producing rely upon the sucker rod system of pumping oil to the surface, the sucker rod is an important key in determining the performance of a given well and the capital investment in that well's equipment. In the early days, when wells were produced at capacity, that capacity was limited by the sucker-rod strength, which in turn was limited by metallurgical know-how. Early sucker rods were thick and heavy, requiring "beefed-up" surface equipment. Improved steels with higher tensile strengths have enabled us to reduce the size of sucker rods, and correspondingly, of surface equipment. The latest development is the ½ in. sucker rod which enables us to pump in tubing sizes less than 2 in. in diameter.

A striking example of the savings possible is shown in Fig. 1. Four possible well completions to the same reservoir are shown. Each is completed to 4700 ft and restricted to 29 bbl of oil per day, in a reservoir capable of ultimately producing 60,000 bbl per well.

A conventional well "A" is fitted with 5½ in. casing, ⅝ in. solid rods and 1½ in. pump, the most popular application for this depth. There is a static load of 8380 lb and a peak polish rod load of 9134 lb. With a counter

Baker's New Snap-Set Duals

–the packers that are bringing single-zone control and simplicity to dual completions

Many operators are coming to feel that the best dual-zone hookup is a modern dual-string hookup. A Baker dual-string completion approaches the control and simplicity (and the flexibility) of a single-zone completion. It is the nearest possible equivalent to two single-zone completions in one well.

What makes this possible? Mainly the development of better upper retrievable packers—Baker's new snap-set duals. They are practical and reliable—and so are the Baker hookups they're used in. Operators all across the country are commenting on their impressive performance.

THE IMPORTANCE OF TWO TUBING STRINGS

Producing through tubing—whether from one zone or two—has its virtues. It protects the casing from corrosion and pressure damage. It encourages easier flow and longer flow, discourages gas separation and loss of natural lift. It makes it easier to run instruments and workover tools, makes artificial lift easier.

It is clear that dual-string production can make the economic success of many wells—provided the hookups are practical. That's where Baker's new dual packers come in.

THE IMPORTANCE OF SIMPLICITY AND FLEXIBILITY

A good dual-string hookup is a simple one. Complexity never had a virtue, never had a payout—especially in a dual completion.

Simplicity is important because the hookup must be reliable and flexible. The key to these things is the upper retrievable packer. That is why Baker has explored every opportunity to simplify the design (see opposite page) of these rugged new dual packers.

A good dual-string hookup is a system—not a random assemblage of parts. This system must satisfy certain requirements. Many of the requirements depend on the upper retrievable packer.

First, both upper and lower packer must pack off and stay packed off. Nothing defeats the economics of a dual completion so readily as a packer that leaks.

Other requirements are equally important. Is it easy to set and unset the upper packer? Is spacing out simple? Can packers be tested before displacement? Can mud be displaced and zones washed while flanged up? Is there provision for simplicity of workover? For artificial lift?

It's all a matter of costs and returns. Baker dual packers were conceived to make dual string completions a paying proposition—and that is what they are doing. With these new packers, dual-zone production has come of age.

RELIABILITY IS BAKER'S STRONG SUIT

Any man who knows the Baker reputation will realize there's a lot of packer and squeeze tool experience behind these new retrievable packers. In fact, Baker's knowledge of these things is unprecedented.

Baker packers have proved themselves in thousands of wells the world over, holding for years, in many cases, against high pressures and withering temperatures. That's a tough proving ground for packing, slips, setting methods, and the like. That is one reason Baker packers are tough and reliable. Reliability is Baker's strong suit.

BAKER RETRIEVABLE SNAP-SET DUAL PACKERS

THERE ARE TWO BASIC MODELS. Each comes in a single-grip and a double-grip version. (Double-grip version has hydraulic hold-down buttons that tighten grip on casing when pressure from below increases.)

PICTURED IS MODEL J (Product 756-J) in the single-grip version. Model J is long-string set. You set it by setting down long string against the resistance of the stinger installed in lower retainer packer.

MODEL K ISN'T SHOWN. Model K (Product 756-K) is short-string set. You set it by setting down short string against resistance of long string. This permits either (a) keeping long string in natural tension, or (b) running another retrievable packer below the Model K.

A close look at Baker Dual-String Hookups - and at the Baker packers and accessories that make these hookups simple, flexible, and practical

TWO SIMPLE PACKERS. Basic to a good dual-string hookup are two types of packers. At bottom, to provide the vital separation of zones, a Baker Retainer Production Packer – the most respected retainer packer in use today. At top, to provide the flexibility that makes dual completions practical, a Baker snap-set dual – the new retrievable packer that is proving itself to the most demanding of operators.

UPPER DUAL PACKER: IT'S EASY TO SET AND RELEASE. When you set a Baker Snap-Set Dual Packer there's no ball dropping, no rotation, no pressuring. You set it by setting down minimum weight. To unset, you pick up. It's just that simple. (One model is long-string set, the other is short-string set. See opposite page.)

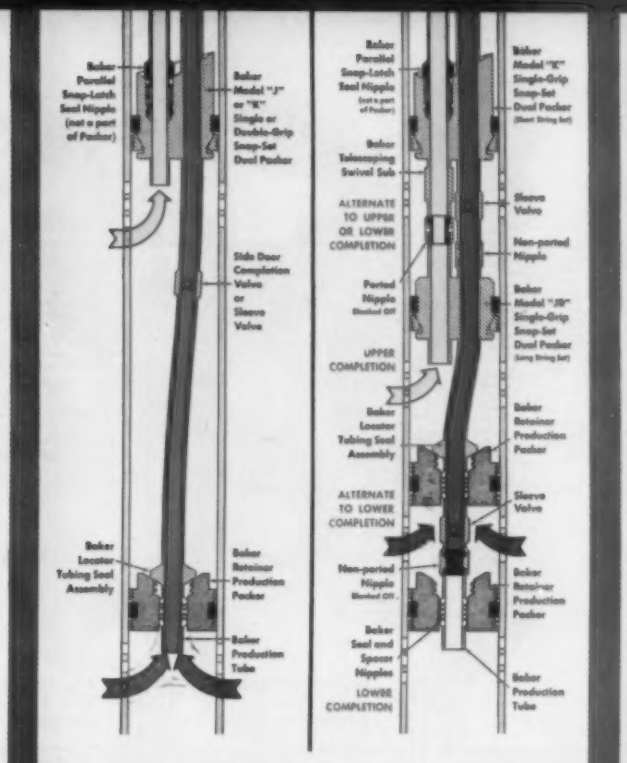
WHAT SNAP SETTING DOES FOR YOU. It's the snap-setting feature that lets you set and unset the Baker dual packer any number of times – for spacing out, testing packers, displacement, etc. There's nothing final in the latch action – no shear pins, for instance, to burn your bridges and make setting an action from which there's no turning back.

HOW CAN YOU BE SURE SHORT STRING IS IN PACKER? Baker makes a special snap-latch seal nipple that seals off the retrievable short string in sealing bore of upper dual packer. This nipple snaps into packer and holds firm. So to make sure it's seated, just stab in and pull back slightly.

YOU CAN COMPLETE FLANGED UP. Using a side door completion valve, or sleeve valve, or other method, you can displace mud and wash in both zones with well head flanged up. You keep the well under complete control.

WHY BAKER DUAL PACKERS HAVE LARGE BORES. Big bores through upper packer offer a real advantage. Packer bores should be as big as the tubing bores so instruments and workover tools won't hang up. In Baker dual packers the bores are that big – there's no restriction, no necking down. How large are the bores? A dual packer for 7" casing is full-opening for two strings of 2⅜" tubing. What makes this possible is simplicity of design. There are no elaborate seals, valves, or other mechanisms to restrict the packer bores.

HOW SQUEEZE TOOL EXPERIENCE CONTRIBUTED TO THE DESIGN OF SUPERIOR PACKING ELEMENTS. Baker dual packers have three packing elements. They're short and rugged – and the upper and lower elements are harder than the center element. It's a design similar to that used in Baker's high performance retrievable squeeze tool – the Full-Bore Cementer, which has been used in thousands of high pressure cementing, frac, and testing operations. The design accomplishes three things: It offers (a) positive packoff with (b) minimum set-down weight, and (c) permits the packer to be repositioned or retrieved easily, because it prevents packing element extrusion without resorting to the metallic back-up rings that sometimes defeat retrievability.


Baker Parallel Snap-Latch Seal Nipple (not a part of Packer)
Baker Model "J" or "K" Single or Double-Grip Snap-Set Dual Packer
Side Door Completion Valve or Sleeve Valve
Baker Locator Tubing Seal Assembly
Baker Retainer Production Packer
Baker Production Tube
Baker Parallel Snap-Latch Seal Nipple (not a part of Packer)
Baker Telescoping Swivel Sub
ALTERNATE TO UPPER OR LOWER COMPLETION
Sleeve Valve
Non-ported Nipple
Ported Nipple Blanked Off
Baker Model "JD" Single-Grip Snap-Set Dual Packer
UPPER COMPLETION
Baker Locator Tubing Seal Assembly
Baker Retainer Production Packer
ALTERNATE TO LOWER COMPLETION
Sleeve Valve
Non-ported Nipple Blanked Off
Baker Retainer Production Packer
Baker Seal and Spacer Nipples
LOWER COMPLETION
Baker Production Tube

LEFT, STANDARD DUAL STRING HOOKUP. It is simple and basic.

RIGHT, LOW COST MARGINALS. This hookup lets you pick up two marginal zones for little more than cost of two extra packers. Marginals can be produced as alternates to primary zones when allowables are reached.

WHAT THE PICTURES CAN'T SHOW. The pictures can't show the stored energy in the tubing string and what it does to maintain packoff. Some dual retrievable packers depend on trapped pressure for a static packoff. In Baker's opinion that isn't adequate, and may easily lead to leakage. It fails to compensate for any packing element extrusion that occurs – and there is usually some. The Baker method does compensate. In a Baker dual packer the stored energy in the tubing string (energy due to set-down weight) acts like a spring to keep the packing elements under a dynamic compression.

SLIP DESIGN PROTECTS CASING. The design of the slips and cones in Baker dual packers protects both casing and packer against excessive radial forces. (This also contributes to easy retrievability.)

IT IS READY TO RUN IN. When a Baker dual packer comes to the well, it's ready to run in. Slips, hold-down buttons, inside seals – they've all been tested and checked out at the factory. Their readiness is known.

SOMETHING TO KEEP IN MIND. Parts are always available, and so is service. Baker operates one of the great domestic oilfield service organizations.

SPECIAL FACTS ON PLANNING DUAL STRINGS
The variables of a dual-string hookup can be many. Baker field staffs are especially well prepared to discuss these things. They have all the latest facts and figures on Baker's intensive continuing study of dual completions. Please contact your Baker branch office for information.

BAKER
SNAP-SET DUAL PACKERS

BAKER OIL TOOLS, INC. | HOUSTON | LOS ANGELES | NEW YORK

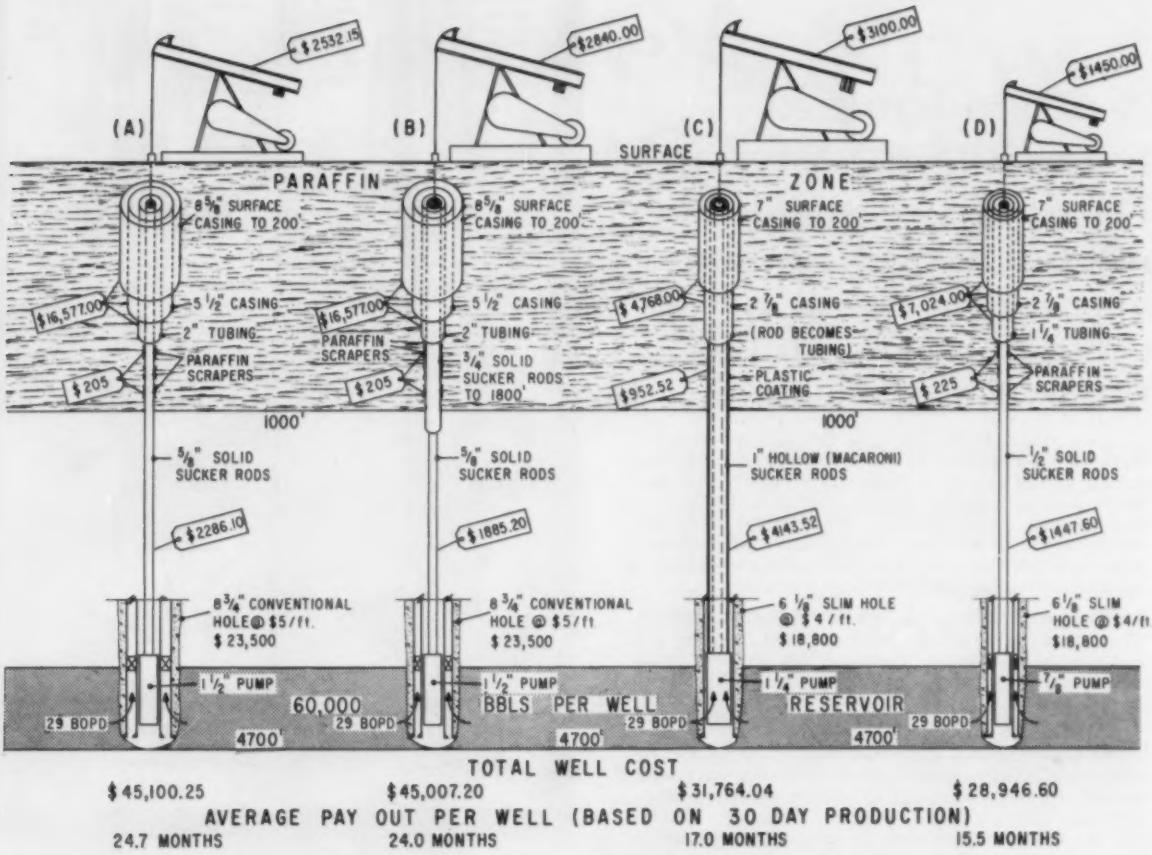


FIG. 1. shows four hypothetical well completion arrangements for artificial lifting of oil production. Costs are given to indicate equipment savings possible when the use of ½-in. sucker rods is applicable.

balance of 6849 lb and stroke length of 34 in. the peak torque is 38,168 in.-lb. A beam pump having a maximum 34 in. stroke and rated at 40,000 in.-lb, seems indicated. This, however, is cutting the safety margin for overload dangerously thin and most operators would go to a larger unit. Total cost of this completion is $45,100. Costs for sub-surface pumps have not been included in these examples as the cost difference would be negligible. Table 1 tabulates the costs for four different completion programs.

In well "B" the operator uses a tapered rod string (¾ in. and ⅞ in.) employing a cheaper carbon manganese rod and a larger pumping unit. The static load is 9254 lb; peak polish rod load 10,200 lb; counter balance 7800 lb; peak torque 41,000 in.-lb. A 57,000 in.-lb unit, the next larger size is used. The total well cost is $44,007. In this case, the saving from using the cheaper rod in a tapered string is nearly offset by the increase in cost of surface equipment.

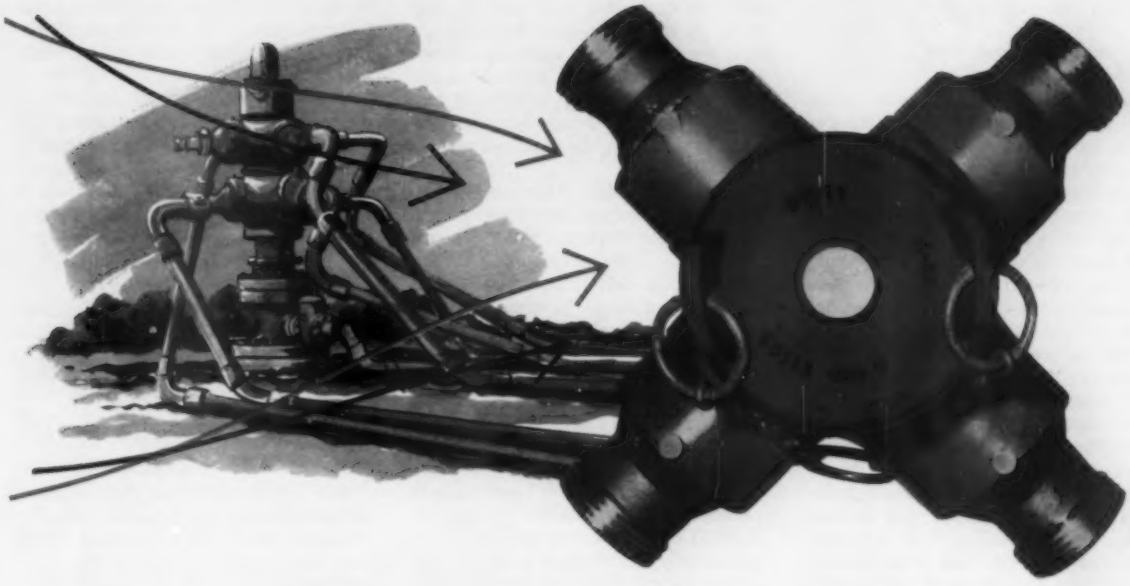
In well "C" we go to a slim-hole completion, using 1 in. macaroni sucker rods with shouldered joints. Cost of tubing is eliminated as the macaroni rod becomes tubing. Total cost of this well is $31,764.

The most economical completion is made in well "D," using ½ in. solid rods, at a total cost of $28,947. The polish rod load for 4700 ft is approximately 4730 lb; the counter balance 3840 lb; the peak torque requirement is 15,800 in.-lb. And rod stress is 24,100 psi. This load could be handled by a 16,000 in.-lb rated pumping unit, however, due to the peak torque requirement being so close to the rated capacity of this gear box, the next size reducer of 25,000 in.-lb capacity was chosen. This application represents the ultimate in equipment economy that could be used to produce the required volume from that depth.

Under the above set out conditions well "A" will require 24.7 months to pay out; well "B" 24 months; well "C" 17 months; while well "D" will require only 15.5 months. It is worth noting here, that if production is only 15 days

TABLE 1. Comparison of Four Well Completion Programs.

	Well A	Well B	Well C	Well D
Drilling cost	@$5′ $23,500.00	@$5′ $23,500.00	@$4′ $18,800.00	@$4′ $18,800.00
Surface casing (200′)	8⅝″ $ 738.00	8⅝″ $ 738.00	7″ $ 538.00	7″ $ 538.00
Casing (4700′)	5½″ $11,938.00	5½″ $11,938.00	2⅞″ $ 4,230.00	2⅞″ $ 4,230.00
Tubing (4700′)	2⅜″ 3,901.00	2⅜″ 3,901.00	None	1¼″ 2,256.00
Sucker rod (4700′)	⅝″ 2,286.10	¾″–⅝″ 1,885.20	1″ 4,143.52 Plastic Lined	½″ 1,447.60
Paraffin scraper (1000′)	205.00	205.00	952.52	225.00
Surface pump unit	2,532.15	2,840.00	3,100.00	1,450.00
Subsurface pump	*	*	*	*
Total capital investment	$45,100.25	$45,007.20	$31,764.04	$28,946.60
Ave. payout/well (30 days/mos @ 29 BOPD)	24.7 mos.	24 mos.	17 mos.	15.5 mos.



FRACTURING *FOCAL POINT*

Halliburton announces *two* new fracturing heads . . . more functional—more versatile than ever. A new cast-steel, four-connection cross-type head, tested to 10,000 psi, which may be stacked to provide any number of connections . . . and a new fabricated steel head—in models providing from four to twelve connections. Although different in construction, both models have the same advanced features. For instance . . .

INDIVIDUAL CHECK VALVES are built in at each connection point. These valves are designed to automatically shut down any back-flow. These full flow valves have proved their merits on countless jobs.

CENTRAL TEST PLUG allows testing through all pump lines and connections *and the fracturing head* up to the well head. You will like the added measure of confidence provided by this design which allows testing of the complete manifolding system . . . not just the pump lines alone.

PERFPAC BALLS may be inserted through special openings which may be provided in the head when it is desired to use this method to block perforations.

QUICK CHANGE CAP and adequate clearance saves time and money. Simplifies running of tools through the head on multi-stage fracturing jobs.

THREE-INCH OR STANDARD TWO-INCH CONNECTIONS may be provided at the head if desired.

Ask about these new Fracturing Heads when you call on Halliburton for your next fracturing job.

FIRST . . . AND STILL FOREMOST . . . IN FORMATION FRACTURING

HALLIBURTON

FRACTURING SERVICES

HALLIBURTON OIL WELL CEMENTING COMPANY—DUNCAN, OKLAHOMA

a month, it will require over 4 years for well "A" to pay out!

For and Against The Half-Inch Rod

Since so much hangs on the sucker rod, it seems prudent for us, at this point, to cast a searching look at the advantages and limitations of the ½ in. sucker rod.

A survey of industry's attitude toward the ½ in. rod and the concomitant principles of slim-hole completion has recently been made. Participants in the survey were also asked to compare ½ in. solid rods with hollow rods.

The survey brought to light some interesting attitudes. Companies which have been using slim-hole techniques have reported quite satisfactory results. There still exists, however, among more conservative elements of the industry, objections if not downright resistance to the ½ in. rod and the slim hole. It was interesting to note that many of the objections seemed to be based upon perception of conditions as they existed several years ago. In other words, many of those questioned seemed not to have kept abreast of the technological developments that have rendered many of these objections invalid. There are also several prevalent misconceptions about the ½ in. rod.

Less Steel Tonnage

Most of those questioned agreed that the primary advantage of the use of ½ in. sucker rods in 2⅞ in. OD or in 4½ in. OD casing completions is that they make possible the use of less steel tonnage, thereby lessening the weight on the surface equipment and reducing the initial capital outlay. One-half in. sucker rods weigh .7 lb per ft, while ⅝ in. weigh 1.15 lb per ft; ¾ in. weigh 1.64 lb per ft; ⅞ in. weigh 2.15 lb per ft; 1 in. weigh 2.90 lb per ft; and hollow 1 in. EUE rods weigh 1.8 lb per ft. This saving of 500 to 2200 lb for every 1000 ft of well depth is not to be lightly dismissed.

One of the more important savings as a direct consequence of the use of ½ in. rods is that 2⅞ in. OD casing is now practical in place of the larger diameter conventional size casing programs.

In light of this development and of reduced well allowables, there remains no technical nor economic justification for the insistence upon larger casing sizes in marginal oil fields.

Scaled Down Surface Equipment

Most of those polled were quick to realize that the savings in tonnage brought about by the use of ½ in. sucker rods and a small plunger resulted in a reduction in the size of surface pumping equipment. It should be pointed out here, however, that more has been done than mere scaling down. A fresh engineering look has been given to the tofal pumping system. The casing program, surface equipment, and sub-surface equipment are all being planned as an "engineered unit" matched to the fluid volume to be produced.

In the past, many wells have sometimes been pumped too long or not long enough. Plunger sizes, all too often, have been determined by the depth of the well rather than by the volume of fluid to be pumped. The result is that many wells are expensively over-equipped.

The selection of too large a plunger results in unnecessarily high loads; while too small a plunger means higher speeds, more frequent stress reversals, and consequent fatigue.

Several manufacturers have designed pumping units outside the API recommended sizes, to come up with a new approach. The result is a design that allows for utilization of the maximum pumping capacity for a given size pumping unit in combination with small bore pumps and ½ in. sucker rods. This design brings about a balance in the maximum utilization of the four variables of long stroke length, beam capacity, peak torque ratings and maximum effective counterbalance. These extra long stroke units satisfy engineering requirements without altering the geometry of basic good design.

It is interesting to note here that through the application of engineering equipment studies, the "slim hole" may become the most efficiently engineered oil well to date.

Half-Inch Rods Are Dependable

The ½ in. sucker rod to date has not experienced any failure known to the manufacturers. In direct contrast, the hollow macaroni rod has tended to fail in the last engaged thread, limiting its acceptance. However, new pressure couplings, currently being field tested, may eliminate this problem.

Solid Rods Historically Preferred

The ½-in. sucker rod is a miniaturized version of the kind of sucker rod that has been used throughout the petroleum history. And there is more engineering history or data available for the solid rod than for the hollow rod. Although there is a minor area of superimposition, in general, ½ in. rods are not in competition with macaroni rods. Differences in depth classifications and in volume capacity determine the application.

Macaroni rods have a greater depth and volumetric capacity, while ½ in. rods should be used in conjunction with a small bore pump, in tubing sizes of 2 in. or less, where the total weight of the fluid and the rod does not exceed 6400 lb. Generally, this means application is restricted to wells of less than 6500 ft.

The half-inch rod was designed for a specific application, and shows up best at depth with low fluid volumes. It has never been intended for use on large-volume wells, but rather as a method of reducing costs on low-volume wells.

Some Comments Analyzed

A number of interesting comments were gathered from this industry survey. The most frequent comments, some correct, some partially true, some wholly erroneous, follow:

ELONGATION

Half-inch sucker rods stretch . . .

For a fixed pump size, the coefficient of sucker-rod stretch increases as the diameter of the rod decreases; therefore it is logical to assume that there will be more stretch in a one-half in. sucker rod than in the ⅝ in.; more stretch in the ⅝ in. than in the ¾ in. However, with ½ in. rods we are dealing with smaller pumps than customarily used. The coefficient of stretch for the ½ in. rod in combination with a 1 in. plunger is .69; this is exactly the same as the coefficient of stretch for the ⅝ in. rod utilizing a 1¼ in. plunger (see Table 2). This means, of course, that in any of the above applications all of these differently sized rods will stretch the same amount. The point is, if you have a fluid problem that can be solved through the use of a 1 in. pump and ½ in. rods, utilization of a 1¼ in. pump and a ⅝ in. rod would necessitate the purchase of larger tubing, pumping unit and prime mover.

RISK

I'm concerned about the stability of those little rods . . .

You can't run ½ in. rods inside of 2 in. tubing . . .

The application of the ⅝ in. sucker rod inside of 2½ in. tubing is widely recognized in petroleum circles as being undesirable because of the possibility of the rod corkscrewing if it is dropped.

In the same manner, the ½ in. sucker rod inside 2 in. tubing is un-

TABLE 2. Coefficients of Sucker Rod Stretch.

Pump plunger size, in.	½ in. sucker rods	⅝ in. sucker rods
¾	.39	.25
⅞	.53	.34
15/16	.61	.39
1	.69	.44
1 1/16	.79	.50
1¼	1.09	.69
1½	1.56	1.00

desirable, unless over-sized couplings are provided on rods to prevent corkscrewing. Both the ⅝ in. rod inside 2½ in. and the ½ in. inside of 2 in. are misapplications, and the problems are exactly the same.

The ½ in. sucker rod was designed to operate in 1¼ in. tubing using a 1 in. OD coupling. If an installation of ½ in. rods in 2 in. OD tubing is desired, an over-sized coupling of 1¼ in. OD is recommended.

There is no reason why the ½ in. rod could not perform satisfactorily in the 2 in. tubing at slow speeds as far as tensile loads are concerned. The operator must be cognizant, however, that the ½ in. rod is more flexible and there is a greater risk of wadding on the downstroke with any restriction in the pump plunger. When ½ in. rods are used in tapered strings inside of 2 in. tubing there is a possibility of corkscrewing and kinking should the excessive weight of the top section drop on the ½ in. section.

Weight added just above the pump on any sized rods to accelerate falling of the rods is considered good practice in many circles, and adds to the stability of the pump plunger.

Half-inch rods have depth limitations . . .

With the present alloy steels such as carbon manganese or nickel moly steel, the ½ in. sucker rod tends to be limited to 6000 to 6500 ft. High tensile steels could perhaps go to 7000 ft, but at this point improved hollow sucker rods begin to come into their own (see Tables 3 and 4).

I can't get paraffin scrapers for ½ in. rods . . .

Paraffin scrapers for ½ in. rods are now plentifully available at a cost of around 20 cents a ft for use in 1¼ in., 1½ in., 2 1/16 in., or 2⅜ in. OD tubing. Experience with paraffin scrapers on ½ in. rods has revealed no problem that it is not common to scraper applications of larger-sized rods in conventional tubing.

There is a shortage of ½ in. rods and accessories . . .

All items that could be defined as accessory equipment are now available in plentiful supply, such as well heads, stuffing boxes, elevators and wrenches.

EQUIPMENT AND SERVICES

I can't get as good equipment or service for a slim hole as for a conventional-sized well . . .

Again, this may have been true at one time. Today, logging and other completion services are available for the slim hole. Manufacturers have

TABLE 3. Specifications — ½-in. Sucker Rod.

	TYPE "A"	TYPE "NM"
TYPICAL PHYSICAL PROPERTIES		
Tensile strength	95,000 psi	93,000 psi
Yield strength	70,000 psi	73,000 psi
Elongation in 8"	19%	21%
Reduction of area	60%	65%
Brinell hardness	192	187
TYPICAL CHEMICAL PROPERTIES		
Type steel	AISI C1036 MOD	AISI A-4621
Carbon	.35%	.20%
Manganese	1.35%	.80%
Phosphorus	.025%	.025%
Sulfur	.025%	.025%
Silicon	.23%	.30%
Nickel		1.80%
Molybdenum		.25%
MISCELLANEOUS ROD INFORMATION		
Rod size	½" x 25' (fully normalized)	
Wrench flat dimensions	⅝" across and ¾" long	
Pin shoulder diameter	1"	
Pin size and thread	¾" x 1" long 10 UNC 2A (unified thd. system)	
Elevator button diameter	⅞"	

COUPLING SPECIFICATIONS—(AISI 8620 Alloy Steel)

Coupling size		Average tensile	Average yield	Overall length	Net area
1" OD	R	90,000 psi	68,000 psi	2.75 in.	.4439 in.²
	H/T	166,000 psi	122,000 psi		
1¼" OD	C/H	147,000 psi	115,000 psi	2.75 in.	.7794 in.²
	H/T	166,000 psi	122,000 psi		

R Regular coupling (unhardened w/229 avg. bhn)
C/H Case hardened (Rockwell "C" 58 avg. for case)
H/T Thru-hardened (quenched and tempered Rockwell "C" 34 avg.)

TABLE 4. Maximum Depth Recommendations for ½-in. Sucker Rods.

X Type "NM" — Calculated at 30,000 lb/sq in. rod stress.
* Type "A" — Calculated at 28,000 lb/sq in. rod stress.
Loads based on specific gravity of one.
Subject to fluid viscosities capable of flow through plungers listed.

	PLUNGER DIAMETER					
	¾ in.	⅞ in.	15/16 in.	1 in.	1 1/16 in.	1¼ in.
2000'	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
4000'	X *	X *	X *	X *	X *	X *
	X *	X *	X *	X *	X *	X *
						4300'
	X *	X *	X *	X *	X *	X *
						4600'
	X *	X *	X *	X *	X *	X *
				5100'	4900'	
	X *	X *	X *	X *	X *	X *
		5500'	5300'	5500'	5200'	
	X *	X *	X *	X *	X *	X *
6000'	X *	X *	X *	X *	X *	X *
	6000'	6000'	5700'			
	X *	X *	X *	X *	X *	X *
	6500'					
	X *	X *	X *	X *	X *	X *
8000'						
Strokes/min	10	11	12	13	14	15
Lgth. stroke	54"	48"	44"	42"	36"	34"
Approx. prod.	25 b/d	30 b/d	32 b/d	35 b/d	37 b/d	43 b/d

Peak torque requirements on above applications vary only slightly from 25,000 in.-lb.

Polished rod load requirements on above applications are in the range of 6000 lb.

Note: Considerable volume increases are possible at lesser depths than maximums shown above.

made available all types of complementary equipment. Remedial services and workover procedures are becoming more effective as we get more slim-hole history.

SUB-SURFACE PUMPS

The efficiency of small-diameter bottom-hole pumps is less than for conventional sizes . . .

In the past, there has been so little use of small diameter plungers that few people are well acquainted with their actual efficiencies. Since the inception of slim-hole techniques, scaling down of pump sizes has brought about no apparent mechanical limitations and, in many instances increased the efficiency above that commonly associated with conventional sized pumps. Reports of efficiencies in excess of 90 percent have been recorded. Most agree that average efficiencies run 65 percent and over.

COST

I really can't see any significant cost advantage . . .

A glance at the figures in Table 1 should convince the most skeptical of the slim hole's economy. In the sample well analyzed, we see how savings in excess of 35 percent may be had with the use of ½ in. sucker rods. Savings, however, may go as high as 60 percent, and do in many cases. The determining factors are depth, fluid requirements, the area being developed, and the extent to which the producer wishes to go to slim-hole methods.

ACCEPTANCE

Our personnel do not like ½ in. rods because they are harder to handle . . .

Admittedly ½ in. rods require somewhat greater skill to handle. But it seems that this skill is a highly desirable one that can be imparted with a minimum of education and carried over to other operations.

This analysis of the most-frequently voiced objections to the use of ½ in. sucker rods indicates that *there are no valid technological or economic objections to the use of the ½ in. rod if it is properly applied.*

Ideal for marginal wells . . .

Most respondents to our survey agree that the only economical way of exploiting marginal wells today is by matching the reserves of a given reservoir to an expenditure for development and equipment that will provide a realistic payout. This means that every acceptable technological and equipment development offering reduced costs must be used.

It is a known fact that in the same area one operator may operate at a fraction of the cost of another. This difference seems to be nothing more than the result of a judicious matching of total investment against reserves.

There may be some inherent disadvantages to cost-reducing procedures, yet, marginal reservoirs must be accepted as economic risks. There is no alternative except abandonment, or, operation at a loss. In such areas, conventional procedures often result in wells that may never pay out. The prudent operator will study total development costs carefully and take adavntage of every possible cost reduction to increase his already marginal profit possibilities.

A vast majority of wells in the United States have production capacities or allowables that can easily be produced through slim-hole completions. In 1959, the average production from 590,000 oil wells in the United States was 11 bbl per day.

MULTIPLE COMPLETIONS

Another specific application for the ½ in. sucker rod is in dually or multiply completed wells where economics and/or limited space inside the small casing means that the well must be pumped through tubing less than 2 in. in diameter. In this case, production volumes will be obviously limited by the capacities of small bore pumps that can be effectively used inside small tubing.

DE-WATERING GAS WELLS

One major gas company in the Texas Panhandle has installed a string of 1¼ in. tubing in combination with a small bore pump, ½ in. sucker rods and a small hydraulic pumping unit to pump accumulated fluids from its gas wells. This rapid accumulation of formation water and condensate had been killing the wells and the company had been paying servicing companies to swab and put these wells back on gas production. The gas is now produced through the casing annulus.

RE-WORKING OLD WELLS

Some producers are going back into old holes where they knew they had a marginal producing formation existing behind the pipe. Because of the economic advantages offered by miniaturized equipment, combined with the small area required in the casing annulus for installation of this equipment, these marginal producing zones can now be economically and satisfactorily dually completed.

Another application concerns old wells that were initially equipped for flush production, but since production has declined the present low volumes are applicable to a ½ in. rod installation.

TAPERED STRINGS

Tapered strings using ¾ in., ⅝ in., and ½ in. rods can, with limited fluid production, satisfactorily produce from 10,000 ft. Usage to date has proved the ½ in. sucker rod has a definite place in tapered strings. The deepest application to date is 8700 ft.

COMPLETION AND PAY-OUT

A prudent operator makes a very careful study of a well when planning his completion program. He must first determine whether oil and/or gas is present in commercial quantities. Next, he must determine the most desirable method of recovering that oil from the standpoint of monetary returns. The cheapest production method is not necessarily the most efficient or the most economical. The nature of the reservoir and the expected life of the well must be taken into consideration. Wise foresight in the initial outlay for completion equipment will aid considerably in reducing future re-completion and re-equipping costs that may arise.

It must be remembered that little is gained by the change of the rod size only. All components must be engineered into a complete pumping system, preferably the most economical one that will produce the amount of oil available at allowable or well capacity rates.

This means that (1) subsurface pump size, (2) rod size, (3) tubing size, (4) casing size, (5) wellhead equipment size, (6) surface pumping equipment, and (7) prime mover size, must all be correlated.

When all of these are designed to produce the actual oil realistically available — not the volume hoped for — there are many applications where the operator has a true economic justification for the slim-hole concept of oil production and use of the ½ in. rod.

SUMMARY

The chief advantage of the ½ in. sucker rod, as has been pointed out, is the economy it makes possible in the entire well program. It is significant that many wells might not be profitable if completed any other way. And any well can be made more profitable if this method is applicable. It is not in competition with larger rods for deeper or higher volume pumping requirements. Generally, it is not in competition with macaroni rods.

It is not intended for large fluid volumes as it performs most effectively producing volumes within its depth and load limitations. This is the true place of the half-inch rod in the petroleum community . . . the optimum economic completion of low volume, relatively shallow production. ★ ★ ★

When this went on location . . .

these went into stock

It may be a little bit difficult to see the connection between a triplex pump being installed on a waterflood project, and a shipment of rubber pails arriving at a nearby National Supply Store—but one is cause, the other effect!

A very important part of the store manager's business is to know what is happening in the territory . . . *and what the happenings mean in terms of new parts or product needs.* When this store manager got word of waterflooding plans, he knew that some of the operators would have to handle alkalis and acids that would mean sudden death to metal containers. So—he ordered rubber pails to do the job.

Currently, we look to thousands of suppliers to provide us with products and the list has to be frequently expanded, as in this instance. The products vary widely—but they all have one thing in common. Each one is made by an established manufacturer, with a proven reputation for quality and reliability. Link - Belt—Westinghouse—Diston—Scott—Marsh—Fyr-Fyter—FMC—Minnesota Mining and Manufacturing—names like these . . . names you know and trust . . . are on every product sold by National. The integrity of the maker added to the integrity of the seller, provides a double guarantee on every item you obtain from National Supply.

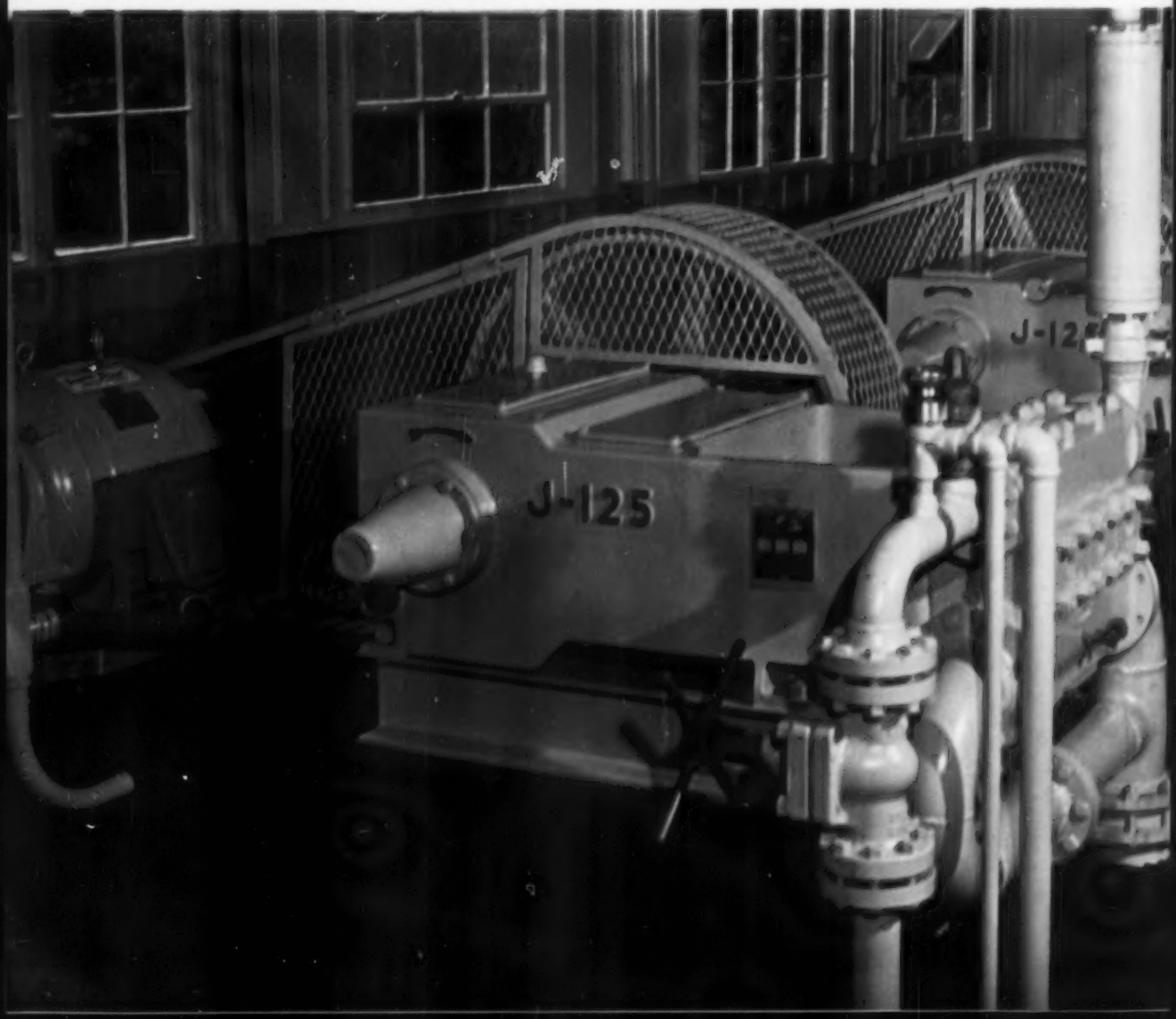
Why National's J-125 Triplex is a smooth running, versatile pump

When any production or drilling unit is made by National, you expect it to have no compromises in design or materials. This is true of the J-125. But check further—see the specific reasons why this pump will perform better than any other in its class. In the J-125, you get—

A BUILT-IN SUCTION DAMPENER—Runs the full length of the cylinder, directly beneath suction valves, to provide optimum dampening effect. The dampener keeps harmful surges from entering suction piping, promotes better filling . . . makes your overall pumping operation smoother and quieter.

FLUID END FLEXIBILITY—Three fluid ends are available for pressures to 6,000 psi (1) low pressure-high volume service (2) medium pressure-medium volume service (3) high pressure-low volume service. Each is available for corrosive or noncorrosive conditions. Ceramic, Colmonoy-coated steel and piston ring plungers (for power oil service) are available in a wide range of sizes.

Four compact J-125 Triplex Pumps are the core of the Mink Island Water Flood plant near New Harmony, Indiana.



Every triplex pump manufactured by National gets a break-in test run up to full rated speed and pressure before it leaves the plant. Fluid cylinders are hydrostatically tested to at least twice rated pressure before assembly of the complete pump.

A DOUBLE EXTENSION CRANKSHAFT — Permits use of a direct connection or a V-belt drive without reversing the crankshaft . . . also enables you to connect auxiliary drives such as chemical or sump pump in addition to the regular drive.

EASY ACCESS TO PLUNGERS, STUFFING BOXES—Ample space in the cradle chamber makes this possible. You can remove plungers or replace packing without removing stuffing boxes. If you choose to remove stuffing boxes, you never disturb the fluid cylinder.

A REPLACEABLE INTERMEDIATE ROD—You replace it without disturbing crosshead or plunger stuffing box. The rod stuffing box seals are grease packed for positive sealing and long service life.

CONTROLLED VALVE FIT—Shouldered, tapered valves give a positive fit. You can remove suction valves without bothering stuffing boxes.

POSITIVE SPLASH LUBRICATION—Used on all pumps operating from 160 to 400 rpm.

LONG PACKING, PLUNGER LIFE—Stuffing boxes fit in a pilot bore in the rib-reinforced main frame, assure proper alignment with plungers. Packing is kept in good condition by lubrication through a grease fitting on the stuffing box.

Don't settle for less than the best in a plunger pump. See the National Supply representative in your area about the J-125.

National High Drive Pumper on the next page . . .

The considerably smaller base required for the High Drive unit makes it ideal for remote locations where foundation costs are high.

NATIONAL HIGH DRIVE Pumper insures easier, low cost installations!

Here's the ultimate in low-cost pumping unit installations—the National *High Drive*. The concrete base for this compact, easy-to-handle pumping unit is much smaller than that needed for other units, so you save on foundation costs. Installation costs are also reduced by the platform-mounted electric motor which permits the use of shorter belts. And because they're elevated, the motor and belts are protected from the damages of blowing sand and high water.

Other outstanding features of the National *High Drive* are:

- Less expensive drive accessories and V-belt replacement
- More compact and easier to handle than pumpers of equal capacity
- Brake lever elevated for convenience
- Elevated platform rigidly constructed

The National representative in your area can furnish more details on these features, as well as all sizes of the National *High Drive* available. Ask him soon.

THE NATIONAL SUPPLY COMPANY

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Equipment layout of West Lisbon centralized plant facilities. Left to right is: heater-treater; water supply well; precipitator and accumulator tanks; water filter; and pump station in right background.

ENGINEERING STUDY SHOWS . . .

Feasibility of Flooding Thin, Tight Limestones

Frank H. Miller, *Chief Engineer,*
and Al Perkins, *Assistant Chief Engineer,*
Spartan Drilling Company, Dallas, Texas

Ultimate recovery to be doubled from Pettit lime unit in North Louisiana put into operation in less than a year from inception and prior to a rapid production decline

IN NOVEMBER 1959, water injection commenced on a carefully engineered waterflood unit in the West Lisbon field of Claiborne Parish, North Louisiana, to increase the ultimate oil recovery from an estimated 1,397,728 bbl to 3,119,961 bbl. Approval by operators, royalty owners and the Louisiana Department of Conservation permitted the unit operator, Spartan Drilling Company, a partnership of Grady H. Vaughn Jr. and Jack C. Vaughn, to initiate water injection less than one year from actual inception of the project. This was just under four years from discovery of the reservoir. Other operators are Texaco Inc., Sinclair Oil and Gas Company, Pan American Petroleum Corporation, Wheless Drilling Company, Crow Drilling and Producing Company, and J. D. Caruthers.

At this writing there are 22 producing oil wells and 13 water injection wells in the field. Production is from the "A" zone of the Pettit limestone which has a maximum net effective pay thickness of a little over 8 ft. Average depth to top of pay is approximately 5450 ft. Porosity ranges from 9 to 21 percent within the 4340.7-acre productive limits. Permeabilities for the predominant part of the reservoir are less than 15 millidarcys and range from 0.8 md to a high of 49.0 md.

Finest in the 1000 lb. working pressure range

This **new** 1000 wp. Tubing Head is safe, compact and economical.

1. 2000 psi Test—1000 psi Working Pressure.
2. The Top Nut contains three hammer up lugs with ample striking surface and tong space. The hammer-up lugs are positioned to facilitate use of automatic slips.
3. The Type "K" Body has a 7⅝" OD 8 RD casing thread on top for the installation of valves or other equipment.
4. The Type "K" Body is furnished with two heavy 2" integrally formed side ports which are leak-proof.
5. The Top Packing Ring is cast by a precision process which provides two perfect halves. When assembled there is virtually no split through which rubber can flow.
6. The Top Packing Element is of Hycar and is the best, most oil and gas resistant compound available for such service. Also, it is newly designed for ease of installation and requires the minimum of make-up to provide a pressure-tight seal.
7. The Top Nut and Slip Bowl will accommodate all sizes of slips interchangeably, 1" through 3".
8. All parts in the Type "K" Head are identified as to Type, Size and where necessary, the Pressure Rating.
9. The Larkin Type "K" Tubing Head is compact, 10¼" overall, and is available with either male or female casing threads, 4½" through 7". The Type "SK" has an overall length of 14½".
10. Mandrel suspension with all the Type "K" quality is available in the Type "MK" Tubing Head.

The Larkin "K" Series Tubing Heads safely and efficiently help you effect **economies** in the 1000 lb. working pressure range. It is an important new addition for this service.

All Larkin Tubing Heads and Casing Heads are available . . . "Through Your Supply Store." Interchangeable parts are immediately available from the Larkin warehouse system which blankets the oil country.

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WAXAHACHIE, TEXAS

LARKIN LEADERSHIP HAS BEEN EARNED BY YEARS OF DEPENDABLE PERFORMANCE

LARKIN
...Through Your Supply Store

DRISCOSE BRIEFS

DRILLING DATA — REPORT 60-1

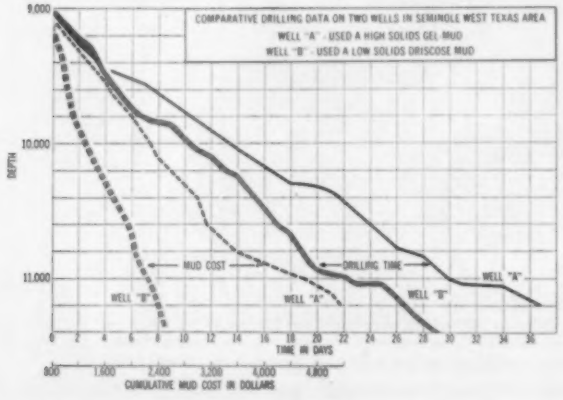
Well Data Evaluations show $15,670 saving when drilling with low solids DRISCOSE* MUD

A study of the data collected on two wells drilled to approximately 11,200 feet in West Texas points out the economy of using low solids Driscose muds. One well was drilled with a high solids gel mud . . . and the other with a low solids Driscose mud.

As shown on the graph below, the well using Driscose low solids mud (Well B, green lines) continued at a faster drilling rate than Well A which used high solids gel mud. The tables of comparative drilling data and costs below tell a more complete story. With Driscose low solids muds, drilling time to 11,200 feet was reduced by 10 days and a total saving of $15,670 was realized.

Low solids mud, containing a minimum of bentonite or other clays, can be tailor-made to meet just about every drilling condition for any given depth. Generally, you start by adding ¾ pound of high viscosity Driscose (99+% pure CMC), 5 pounds of bentonite, and 6 to 8 percent diesel or light crude per barrel of water. This furnishes mud with a viscosity of approximately 16 centipoises. More or less bentonite may be added depending upon the desired viscosity and the quality of the water used. When native mud is used, bentonite is seldom required at the start.

Low solids muds are maintained by adding enough water to hold weight and drilled solids to the desired level, maintaining oil level, and keeping the desired viscosity by adding high viscosity Driscose and bentonite (ratios varying from 1:4 to 1:8, Driscose to bentonite). If needed, a solids settling surfactant emulsifier may be employed to aid in emulsifying oil and settling drilled solids.


COMPARATIVE DRILLING DATA ON TWO WELLS IN SEMINOLE WEST TEXAS AREA
WELL "A" - USED A HIGH SOLIDS GEL MUD
WELL "B" - USED A LOW SOLIDS DRISCOSE MUD
DEPTH
9,000
10,000
11,000
MUD COST
DRILLING TIME
WELL "A"
WELL "B"
WELL "B"
WELL "A"
WELL "B"
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36
TIME IN DAYS
800 1,600 2,400 3,200 4,000 4,800
CUMULATIVE MUD COST IN DOLLARS

DRILLING DATA

	Well "A" Gel Mud	Well "B" Driscose Mud
Interval Compared	9,000'—11,200'	9,000'—11,200'
Number of Bits (8¾)	38	28
Rotating Hours	344.5	230.5
Average Feet per Rotating Hour	6.4	9.5
Average Feet per Bit	58	79
Increase in Penetration Rate	—	48%
Increase in Footage per Bit	—	36%
Mud Costs	$5,200	$2,600

SAVINGS

10 Days Drilling @ $1100 per Day	$11,000
10 Bits @ $207 each	2,070
Mud Savings	2,600
Total Savings	$15,670

The outstanding advantages of Driscose low solids muds are: (1) the reduction of pressure surges both in the hole and at the annulus, (2) a low water loss which reduces the deposition of filter cake on well bore, (3) mud containing few solids and possessing a high resistance to contaminants, and (4) increased penetration rates with extended bit life.

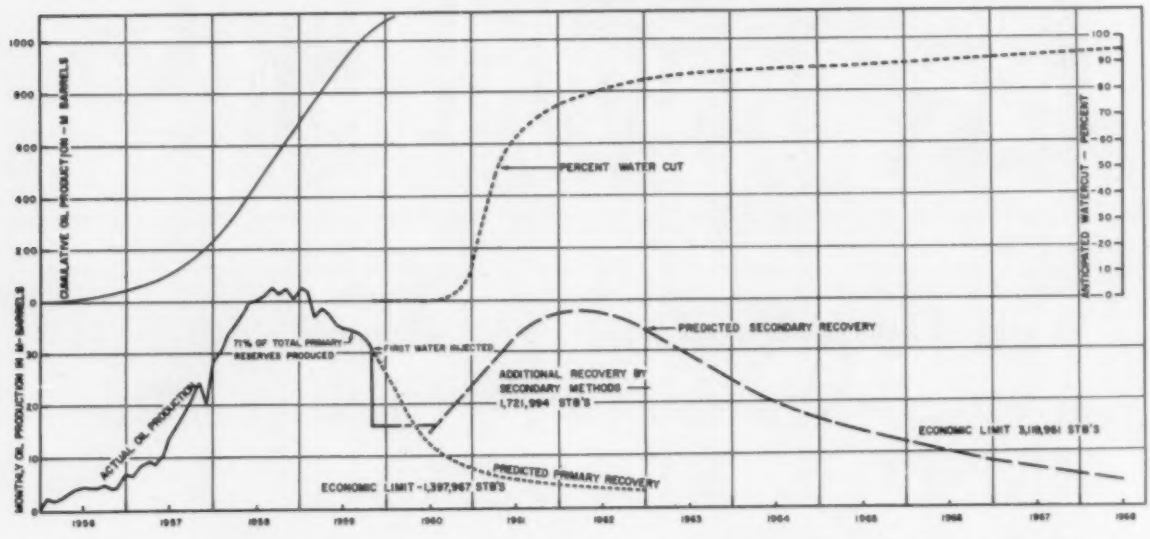
More complete data on Driscose may be obtained from your mud dealer—or by writing . . .

*A Trademark

DRILLING SPECIALTIES COMPANY
Bartlesville, Oklahoma

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

FIG. 1. **Field performance history** and predicted performance of the West Lisbon Pettit Lime Unit of Claiborne Parish in North Louisiana. Monthly oil production was cut back in October 1959 upon conversion of 13 producing wells into injection wells.


CUMULATIVE OIL PRODUCTION – M BARRELS
MONTHLY OIL PRODUCTION IN M+ BARRELS
ANTICIPATED WATERCUT – PERCENT
PERCENT WATER CUT
ACTUAL OIL PRODUCTION
71% OF TOTAL PRIMARY RESERVES PRODUCED
FIRST WATER INJECTED
PREDICTED SECONDARY RECOVERY
ADDITIONAL RECOVERY BY SECONDARY METHODS – 1,721,994 STB'S
ECONOMIC LIMIT 3,119,961 STB'S
PREDICTED PRIMARY RECOVERY
ECONOMIC LIMIT – 1,397,967 STB'S

How Field Was Discovered And Developed

The extremely thin Pettit "A" zone limestone was actually "discovered" on an electric log run in Spartan Drilling Company et al's A. G. Killgore Unit "A" 1, completed at 11,325 ft on October 13, 1955 in the northwest portion of the field. The zone was not perforated or tested in this deep well. Confirmation of the productivity of the Pettit lime "A" zone came with the drilling and completion of Spartan et al's A. G. Killgore Unit "B" in the same area of the field on December 18, 1955. Initial potential was 430 bbl per day of 34.5 deg API gravity oil from perforations at 5323-30 ft. Flowing pressure was 350 psi on a ¼-in. choke with a gas-oil ratio of 465.

In accordance with a ruling by the Louisiana Department of Conservation, subsequent wells were drilled on an 80-acre spacing pattern. All wells were treated upon completion with an acid-fracture and potentials ranged from 10 to 500 bbl per day. Although most wells came in flowing, bottom-hole pressure decreased rapidly and at the present time only one well is flowing. Original bottom-hole pressure was 2550 psia, but declined to approximately 1000 psia prior to water injection. Original gas-in-solution was determined to be 395 cu ft per bbl by reservoir fluid analysis. This reservoir has a solution gas drive mechanism with no free water or gas cap present.

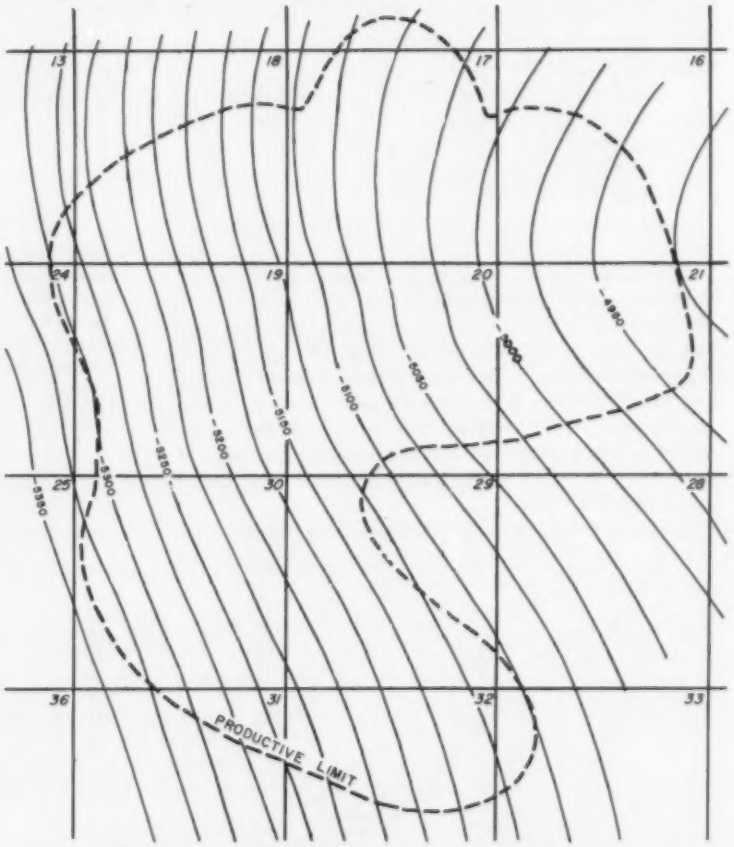


FIG. 2. **Sub-sea structure contours** on top of Pettit Lime "A" zone show reservoir to be westward plunging structural nose. Productive limits established by porosity and permeability development.

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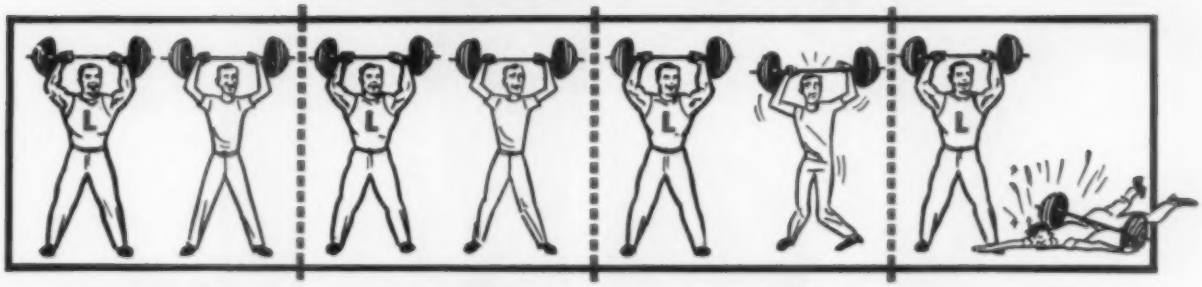
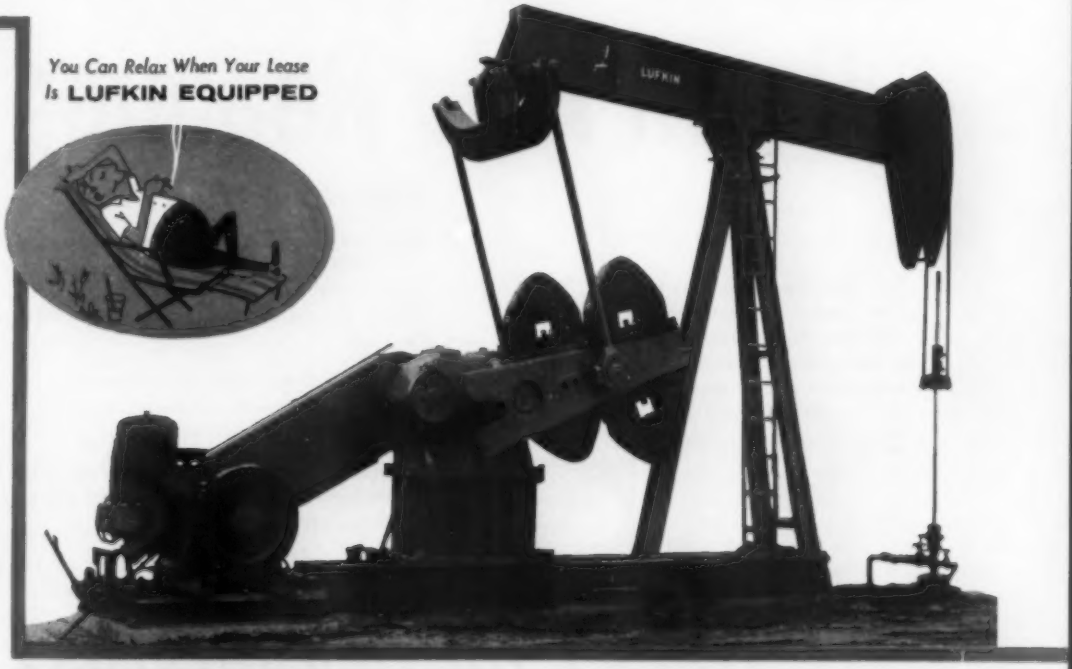
"H--- for STOUT"

has been the LUFKIN motto from the very beginning . . . a policy that has given LUFKIN units a reputation for UNSURPASSED ENDURANCE and PERFORMANCE . . .



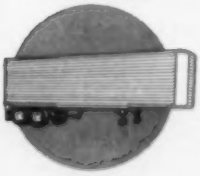
GOOD ENOUGH | WE WONDER . . . | . . . LATER | WUPS

You Can Relax When Your Lease Is **LUFKIN EQUIPPED**

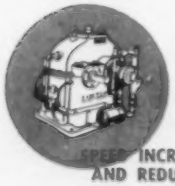


PUMPING UNITS

GAS ENGINES



TRAILERS



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Six cutter types for every formation
Three, six or *nine* point body styles
Size ranges for *all* hole diameters

and you have an unlimited selection of Grant Reamers for reaming any well you drill . . . stocked and serviced by Grant in active areas *everywhere*.

It pays to ream *right*. And to use the *right* reamer, call Grant—*because only Grant makes them all!*

This is just one of the three *families* of Grant Tools made for reaming, hole enlarging and stabilizing. For full information on these, and a wide range of other down-hole and surface tools made by Grant, send for your copy of the complete Grant Catalog today, or see the Grant section of Composite Catalog!

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FOR FURTHER INFORMATION ON
ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Produced fluid inlet manifold connects to free-water knockout at right. In background left to right are water filter; filter backwash pump and accumulator tank.

Level control on accumulator tank controls output of water supply well. Vernon Gates, pumper, makes adjustment.

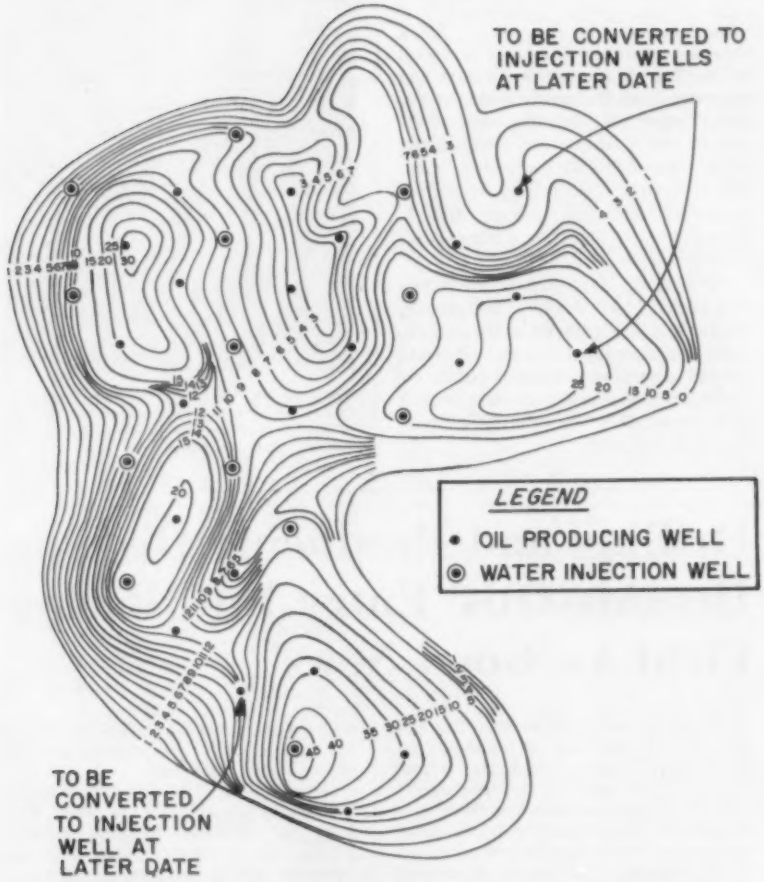

TO BE CONVERTED TO INJECTION WELLS AT LATER DATE
LEGEND
OIL PRODUCING WELL
WATER INJECTION WELL
TO BE CONVERTED TO INJECTION WELL AT LATER DATE

FIG. 3. Iso-permeability map of Pettit Lime "A" zone was constructed from core analysis data and microlog interpretation. Cores in most wells were taken at half-foot intervals throughout the pay zone.

Production history of the field to February 1, 1960 and predicted performance is shown in Fig. 1.

Brief On Geology

The Pettit is an oolitic lime of Lower Cretaceous age and less than 15 ft in total thickness in the area. The reservoir is on a westward plunging structural nose (see Fig. 2) with limits of production determined by porosity and permeability development. Generally, the zone tends to become shaly and tight on the flanks.

Reservoir Limits and Reserve Calculations

Reservoir data were obtained from analysis of cores taken through the productive interval of all wells drilled. Additional data were provided from laboratory tests with respect to capillary effects, waterflood susceptibility and reservoir fluid analysis. These data combined with log studies provided most of the information required for a complete reservoir study from which the engineering maps were based.

Net effective pay thickness was established by limiting measurement to that section which showed a permeability of 0.8 md or more. Since a majority of the core analyses were made from two samples per foot, maps were constructed down to the half foot and interpolated to zero. In a few instances where core samples were lost, data were taken from micrologs. The iso-permeability map shown in Fig. 3 was constructed from core analysis data and microlog interpretation.

OTIS PRODUCTION NEWS

Volume I, Number 1 **Otis Engineering Corporation • Dallas** *Production Equipment and Services*

Special Report from West Texas

Otis Production Packers Hold Where Others Fail

High Pressure, Strain, Tubing Vibration in Gas-Injection Wells Cause Bodies of Competitive Packers to Part

MIDLAND — Type WA Otis Production Packers have proved to be the solution to a serious problem encountered by a West Texas operator on a secondary recovery project. The problem was to find a packer that would stand the stress and vibration of the tubing in a number of high-pressure gas-injection wells.

The wells involved were being used to inject gas into the Devonian at approximately 12,500 feet. Injection rate was 2½ M.C.F.D. at 7,500 P.S.I. Due to vibration created by this high rate of injection, the tubing was set in tension with a minimum of 25,000 pounds' strain. These conditions apparently proved too strenuous for the packers used in the initial completion for they disintegrated shortly after the wells were put into operation.

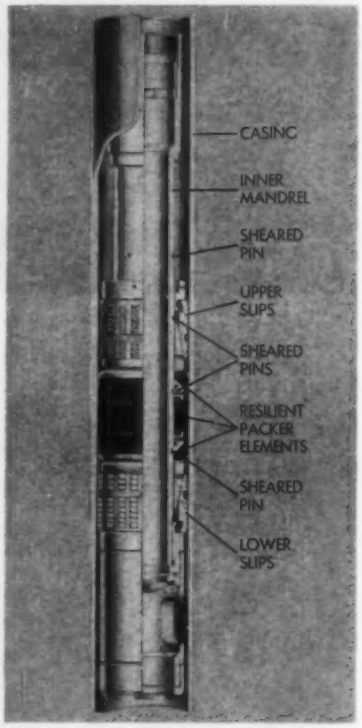
In analyzing this producer's problem, Otis packer specialists from the Odessa office felt confident the Type WA Otis Production Packer would stay in the hole in spite of the adverse working conditions because of the packer's "floating mandrel" design.

See diagram this page

This feature, unique among permanent-type retainer packers, is designed to prevent problems such as this which result when a packer's inner mandrel is permanently attached to the slips or packer body.

Unlike the packers originally used in these wells, the inner mandrel of the Type WA Otis Packer is not pinned to either the upper or lower slips, or the rubber element assembly, once the packer has been set. The mandrel is free to travel up or down within the outer packer body approximately 8 inches before being confined by a shoulder at either end, and is sealed off and held in position by O-rings and pressure from the compressed rubber packer elements. In this way, vibration or movement of the tubing string when transmitted to the packer mandrel is partially absorbed by the rubber packer elements first, and not directly transmitted to the slips or the outer packer body.

As a result, Type WA Otis Production Packers have replaced the packers originally used in these injection wells and the operator reports all have proved satisfactory. Several additional wells are to be drilled for this project and Type WA Packers have been specified for each.



When setting the Type WA Otis Production Packer, all pins holding the slips and resilient packer elements in the running position are sheared and the mandrel is free to float.

© 1960 O.E.C.

Drilling and Producing Division Heralds Otis' Entry Into Packer Field As 'Good News'

DALLAS — The news that Otis has acquired a new line of field-proven production packers and bridge plugs, and is now offering a "packaged" well completion service, has been well received by the drilling and producing division of the petroleum industry.

For the last 25 years, producing companies and packer manufacturers both have looked to Otis for guidance when engineering difficult well completions. Now, with its own line of packers, Otis will provide the industry a "packaged" well completion service to include both engineering and all sub-surface equipment.

The present line of Otis packers includes a series of Type WA Wire Line Set Drillable Retainer Packers which can be set on any wire line pressure setting tool; three tubing or drill pipe set packers which carry the designations Type TA, TB, and TE; a Type RA Retrievable Packer designed to be set in tension or com-

(See "Good News," Page 2, Col. 2)

Better Production Tools Through Research

Otis-Engineered Dual-Completion Saves Tubing Job 30 Days Following Initial Completion

THOMPSON CREEK FIELD, MISS. — A well, dually-completed in this western Mississippi field in November, 1959, produced approximately 200 B.O.P.D. from each zone immediately following completion, however both zones had to be put on pump in less than thirty days due to a decrease in bottom-hole pressure. The well completion, engineered by Otis specialists in that area, was designed to permit the operator to flow this well as long as economically feasible, then put both zones on pump without pulling tubing.

The well was completed with two packers, a dual and a single, a Type S Otis Landing Nipple and a Type A Otis Sliding Side-Door between the two packers for plugging and circulating purposes, and two Type S Otis Landing Nipples above the top packer in each string.

See schematic diagram — right

The conversion of this well to artificial lift was accomplished by landing Type S Otis Pump Locators and Hold-Downs in the top S nipple of each string and installing the pumps. As the zones deplete, the pump locators and hold-downs may be reset in the lower nipple of each string simply by pulling the pumps, retrieving the locators and hold-downs, changing the selective keys on the locators, and re-running the tools to the lower nipple. By using Type S Otis Landing Nipples instead of regular A.P.I. pump seating nipples, the tubing remains full-opening to permit running through-tubing perforating guns, bottom-hole pressure bombs, and other wire line service tools. Also, plug chokes and other Otis sub-surface flow control equipment may be set in any of the S nipples should it become necessary.

Good News

(Continued from Page 1)

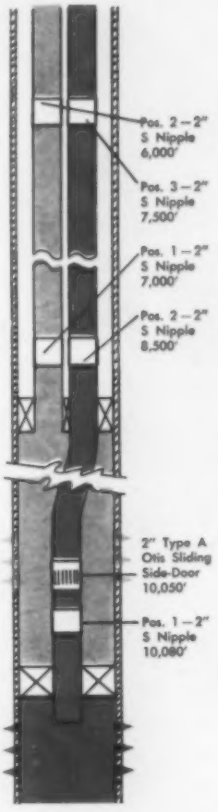
pression without modification; the Type HS Retrievable Isolation Packer which is set hydraulically, and two retrievable collet-type packers — one for slim-hole work and the other a regular casing collet-type packer.

A stepped-up research and development program is expected to produce several new types of packers in the immediate future to further round out the line of packers Otis already offers.

As part of the company's expansion program into the packer and bridge plug field, highly skilled packer specialists have been added to the staff of each Otis division. These men, working with other Otis well completion experts, form a team that operators can look to for a "packaged" well completion . . . as a single supply source for *all* necessary sub-surface completion equipment — from the wellhead to the plug on bottom.

Tool and Service Information

For additional information on any of the equipment reported in this issue of the Otis Production News, contact your nearest Otis office or write Otis Engineering Corporation, Dept. 1-P, Box 35206, Dallas 35, Texas. You'll find your Otis specialist ready to help you — anxious to serve you.


Pos. 2 – 2" S Nipple 6,000'
Pos. 3 – 2" S Nipple 7,500'
Pos. 1 – 2" S Nipple 7,000'
Pos. 2 – 2" S Nipple 8,500'
2" Type A Otis Sliding Side-Door 10,050'
Pos. 1 – 2" S Nipple 10,080'

OTIS

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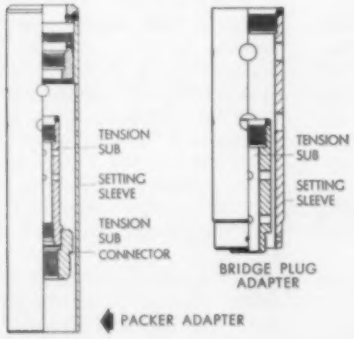

New Otis Packer and Bridge Plug Pressure Setting Tool Adapter Kits

Special pressure setting tool adapter kits have been developed to permit Type WA Otis Production Packers and Otis Wire Line Bridge Plugs to be set on the No. 20 pressure setting tool. Both of the adapter kits are extremely simple in design and can be easily made up with the setting tool.

The packer adapter kit consists of a tension sub, setting sleeve, and tension sub connector which is made up on top of the WA packer on the rig floor. The adapter for the bridge plug consists of only two sub-assemblies, a tension sub and a setting sleeve.

Both kits have been extensively tested in the laboratory and in the field, and neither has failed to operate as designed.

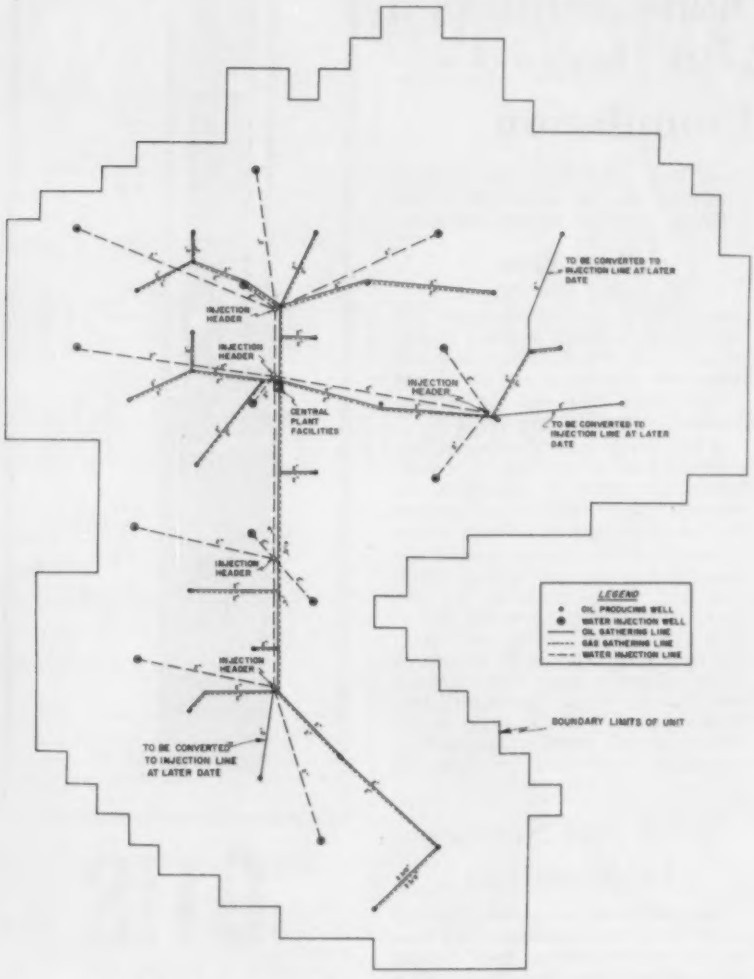

FIG. 4. **Surface hookup for waterflood** in West Lisbon Pettit Lime Unit, showing location of central plant facilities which include centralized oil storage and water handling equipment. Note that three systems are indicated: water injection lines, gas gathering and oil gathering lines.

Reserves for each tract were determined by applying a 10-acre transparent grid overlay to the various maps. Values were picked from each map for each 10 acres, from which reserve figures for each tract in the field were calculated by the usually accepted volumetric method with an electronic computer.

PREDICTING RESERVOIR PERFORMANCE

Reserve calculations showed the Pettit lime "A" reservoir originally contained 11,800,728 stock tank bbl of oil and 4,661,294 Mcf of gas. Studies of other solution-gas drive Pettit reservoirs in the area revealed that under primary depletion practices, only about 14 percent of the original oil in place would be recoverable. Deducting the undrilled tight, thin sections around the field's edge which would contribute little to the cumulative primary production and employing a 14-percent recovery factor, the primary production for the Pettit "A" zone was reduced to 1,397,967 stock tank bbl.

Studies of production histories of other Pettit fields in the area also showed that when an average of 71 percent of the primary recoverable oil was produced, oil production declined sharply and entered the stripper phase in a relatively short time. Again applying this analogy to West Lisbon, since the reservoirs are quite similar in nearly every respect, the predicted future primary performance of West Lisbon using a 14-percent recovery factor may be seen in Fig. 1. The production curve shows that 71 percent of the primary recoverable oil was produced by September 1959 and that rapid deterioration occurred as expected. Under continued primary production practices, the West Lisbon field would have reached its economic limit by the end of 1962.

Therefore, it was essential to commence water injection immediately in order to halt further decline in bottomhole pressure. Spartan Drilling Company instigated a program with the full cooperation of all operators waiving the usual committee procedure resulting in the official unitization of the field by October 1, 1959. By November 8, 1959, water injection was begun into the Pettit lime.

Predicting Secondary Recovery Performance

Predicted performance and life expectancy of the West Lisbon waterflood was based on past performance of the waterflood production history for the Southwest Lisbon Pettit reservoir. At the time this study was made, it was estimated that the latter field had already been in operation for about 75 percent of its expected life. This performance allows a very close determination of the actual primary plus secondary recovery figure, which is now expected to reach approximately 32.8 percent of the original oil in place.

Judging from the results of the Southwest Lisbon waterflood, it appeared reasonable to assume a comparable primary plus secondary recovery factor of 32 percent for the West Lisbon field. Information obtained from restored state waterflood susceptibility tests conducted in the laboratory on West Lisbon Pettit cores also served to support the recovery figure. Based upon the area affected by waterflooding, 32 percent of the original oil in place resulted in an ultimate recovery of 3,119,961 bbl from the West Lisbon Pettit for both primary and secondary operation. When water injection started in November 1959, 75.6 percent of the primary recoverable oil for the field had been produced. Predicted performance under waterflooding is shown in Fig. 1. Shape of the production curve was based on consideration of anticipated injection rates and production practices. The curve shows that secondary depletion will result in an additional recovery of 1,721,994 bbl of oil over and above recovery expected

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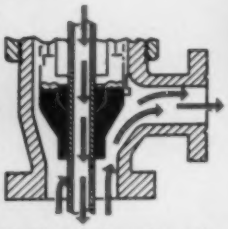
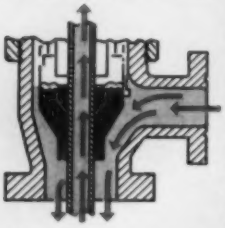
DRILLING WITH AIR OR GAS?



There is a steadily growing use of air or natural gas to replace the mud column in many drilling operations. Advantages include faster drilling rates, more footage per bit, no "lost circulation" problems, and greater production recovery.

The ideal unit for sealing off around the drill string and maintaining safe pressure control is the Shaffer Combination Rotating Blowout Preventer and Stripper. It not only permits the well to be drilled safely, but also it can be adapted to be used as a casing stripper during casing operations to maintain pressure control.

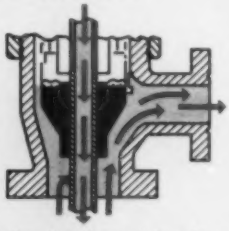
DRILLING WITH REVERSE CIRCULATION?



Reverse circulation is another of the modern drilling techniques that have definite advantages in certain types of formations. By returning the cuttings through the inside of the drill string, higher return velocities are obtained at lower pump pressures (and lower pressures on the formations). The higher velocities insure larger cuttings being returned from the formations, in many cases eliminating need for coring and thus saving rig time. Also by carrying large cuttings away faster, bit life is lengthened and drilling time is reduced.

These and other advantages make Reverse Circulation techniques worth investigating — and here again, the key to proper operation is a Shaffer Combination Rotating Blowout Preventer and Stripper to seal off the drill string and to control circulation pressure while drilling.

NORMAL DRILLING OPERATIONS?



Here again, this Preventer and Stripper insures safety and efficiency to a degree unmatched by any other type of hook-up. The unit seals off around the varying diameters of the drill string — pipe, couplings, tool joints and drill collars — adjusting itself **automatically** to the various diameters and shapes. It even seals safely around such shapes as squars, hexagon or octagon kellys. And the seal is automatically maintained as long as the drill string is in the hole. No valves to operate, no levers to move — nothing to remember or forget when pressure emergencies threaten.

GET ALL THE FACTS

on the uses and design features of this unit by sending for the helpful 36 page brochure. It's free to qualified field personnel, engineers and executives!

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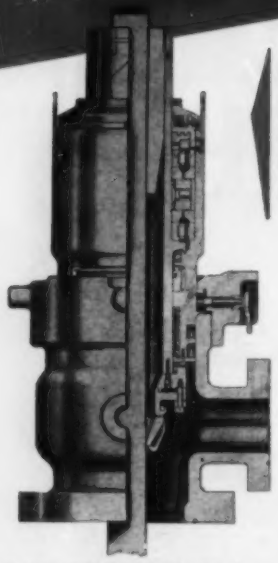
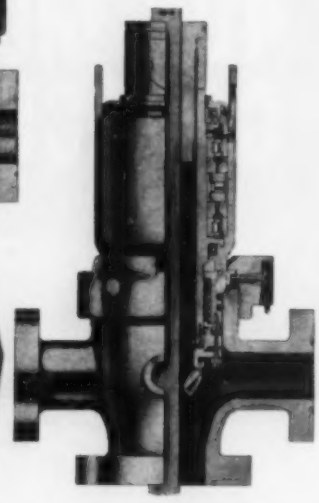


USE THE TYPE 50

for all kinds of drilling operations, including drilling through 10¾" casing and larger.



USE THE TYPE 51

for blowout protection in slim hole drilling, drilling-in, production jobs, reworking of wells and similar applications.

Shaffer Combination Rotating Blowout Preventers and Strippers are known throughout the industry for the unequalled *automatic* protection they provide against pressure emergencies. Nothing to remember—or forget—when pressure emergencies threaten, because this equipment automatically seals off around the drill string as the tools are lowered into the well . . . *and maintains this pressure-tight seal—without attention—throughout all subsequent drilling operations.*

Whether for big jobs (Type 50) or small (Type 51), both types can be used for the various applications outlined at left.

See your nearest Shaffer representative for complete details on these units. Or write direct.

Send for your free copy of the complete Shaffer Catalog.

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Typical water injection manifolds equipped with water meters, throttling valves and injection pressure gages on each injection line.

from continued primary operation.

Because of the irregular and streaky permeability in the Pettit lime, it is expected the water will channel rapidly through the more permeable streaks leading to an early water breakthrough. This was experienced in the Southwest Lisbon field. Fig. 1 shows the expected water cut under waterflooding. While it is hoped that proper injection rates can delay the water breakthrough for at least seven months after first injection, water cuts in excess of 80 percent will be evident within two years. It is anticipated that the West Lisbon flood will become more of a washing or leaching action and will require handling of large volumes of water to sustain oil production.

PLAN OF OPERATIONS AND SURFACE EQUIPMENT

The Flood Pattern

A modified five-spot flood pattern

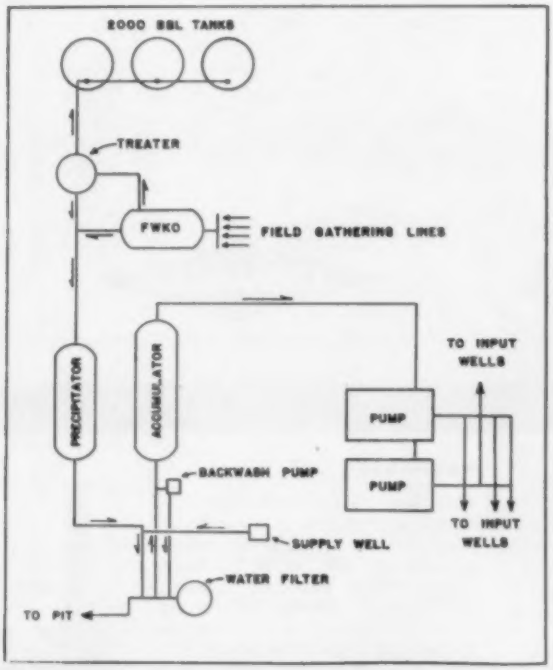

FIG. 5. **Central plant facilities** for handling produced fluids, water treating equipment and injection pump hookups.

Pump station is equipped with two of these skid-mounted gas-fueled engine-powered triplex plunger pumps. The second pump unit is a standby until larger injection volumes are required. Both units equipped with safety shut-off controls for lubricating oil, temperature and discharge pressure.

WITH DOWELL ENGINEERED ACIDIZING . . .

OPERATOR MAKES WELL BETTER THAN NEW

Engineered acidizing by Dowell is helping operators improve wells in many ways.

Dowell engineers use the "Acid Guide*" to design treatments for better results, lower costs, or both. Also, more and more, Dowell-developed services such as Abrasijet* (abrasive jetting service) and Rockshock* (implosive formation-treating service) are being used to pave the way for more effective acid treatments. In some instances, their use has resulted in successful treatments under conditions that were considered impossible to overcome.

Here are four recent treatments that illustrate how Dowell engineers use acid to help operators get good wells. The first is a case where engineered acidizing actually made a well better than new.

PRODUCTION INCREASED 2½ TIMES AND GAS/OIL RATIO GREATLY IMPROVED

Production from a Pecos County, West Texas well had declined from 250 to 180 bopd. Original gas/oil ratio was 1077 but had increased to 1560. Then an acid treatment, engineered with the aid of the "Acid Guide," increased production to 460 bopd. The treatment also reduced the gas/oil ratio from 1560 to 770.

The original completion was made in June, 1954. Perforations were into the Silurian (Montoyo) pay from 5118 to 5129 feet.

The engineered acid treatment recommended by Dowell used 5000 gallons of acid with a Dowell demulsifying agent added. Injection rate was five bpm at 2200 psi.

Despite the fact that the well is more than five years old, production is now considerably better than it was when the well was new.

WATER SHUT OFF--OIL PRODUCTION RESTORED WITH ABRASIJET AND MUD ACID

In Jones County, North Texas, an old well had gone to 100 per cent water. The well was completed open hole in the Palo Pinto sand between 3100 and 3260 feet. A Dowell water locator showed water entry in the zone below 3230 feet, so this zone was squeezed off with cement.

Then, Abrasijet was used to enlarge the hole and clean the formation at the most productive levels. Next, the well was acidized with 250 gallons of Mud Acid.

After clean-up, production was 56 bopd with **no water.** The operator saved a well that might otherwise have been abandoned.

KENTUCKY OPERATOR GETS 85 BOPD WELL IN AN AREA OF 15 BOPD PRODUCERS

A Dowell acid treatment resulted in a 30-day test of 85 bopd in an area where most wells drop to 15 bopd in the same period.

The well was in Muhlenburg County. Completion was through perforations into the O'Hara formation.

The Dowell treatment consisted of 1500 gallons acid with demulsifying and silicate control agents added. The operator credited these Dowell addition agents with the good results obtained.

DOWELL CUTS THROUGH TWO-FOOT MAGNESIUM BRIDGE PLUG IN SIX MINUTES

Dowell was called to acidize out a 9⅝" magnesium bridge plug that had set prematurely 90 feet below surface. The operator was afraid to drill because he could not get enough weight on the bit to balance the 2000 psi pressure below the plug.

Dowell engineers suggested the use of Abrasijet with acid. A special tool with two downward-pointing jets was run on 3½"-drill pipe and set about one inch above the plug. The pipe was held down with chains.

1000 gallons Dowell acid, carrying one pound sand per gallon, was pumped through the tool at 2500 psi. After six minutes, gas began to blow out the annulus, allowing pressure to equalize above and below the plug. The operator then went in with a bit and knocked the plug to bottom without difficulty.

Here is another example showing how Dowell uses acid **and engineering** to solve difficult problems and reduce costs. The plug was cut through in six minutes as compared to a normal drilling time of at least four hours.

Modern, **engineered** acid treatments as offered by Dowell can help producers increase their profits more than ever before. Call your Dowell representative for prompt service or detailed information. Dowell services and products are offered from more than 150 offices and stations in the United States, Canada, Venezuela and Argentina. Dowell, Tulsa 1, Oklahoma. *Dowell Trademark

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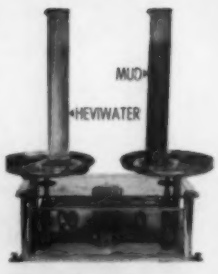
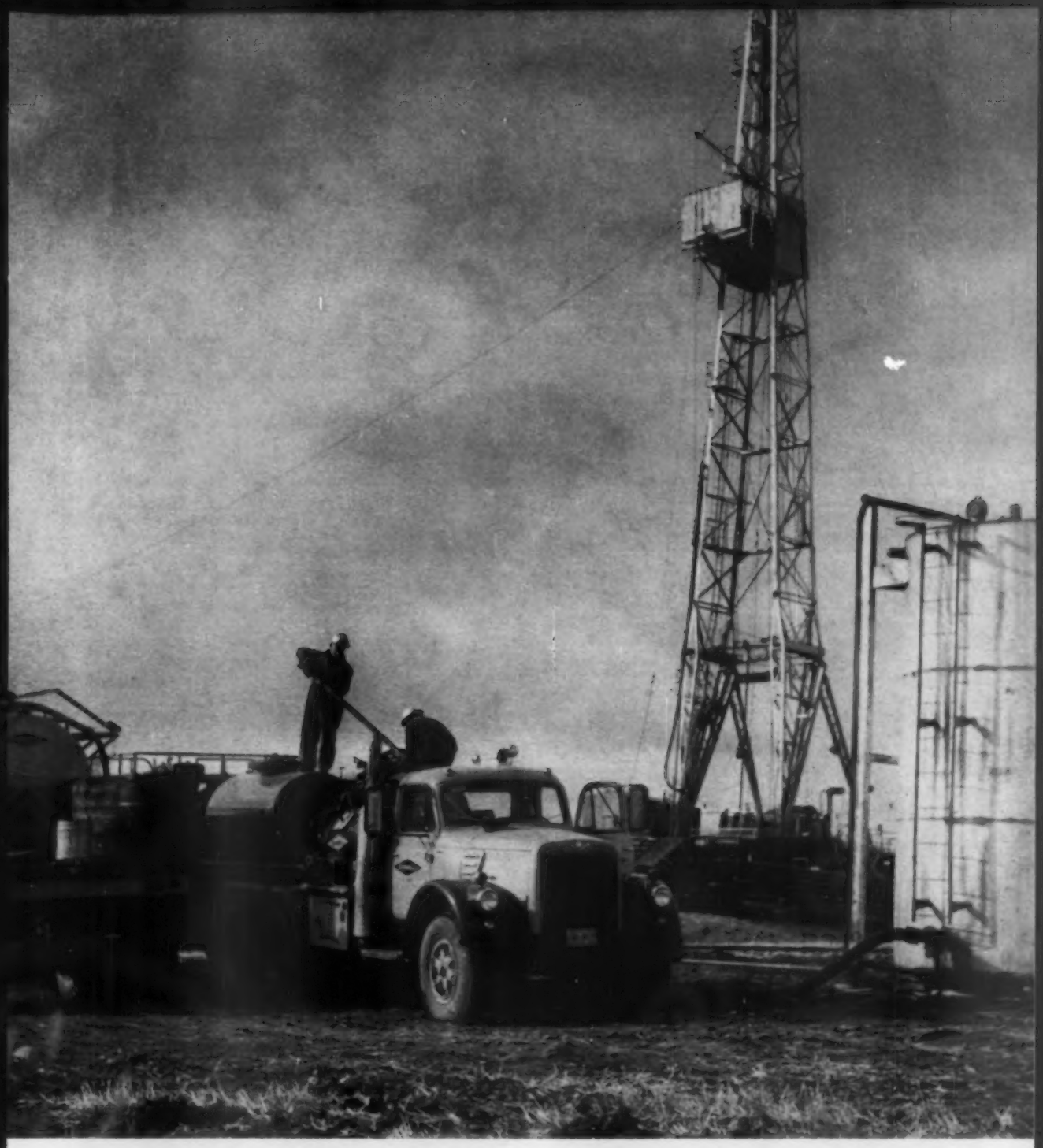
This new well completion fluid comes ready-mixed in a variety of weights. It is designed to be left, instead of mud, in the annulus above packers; also used as a protective fluid during perforating. Packer sticking and formation damage are avoided because it contains no undissolved solids. Presently stocked at Berwick, La.; can be made available at all Dowell stations.





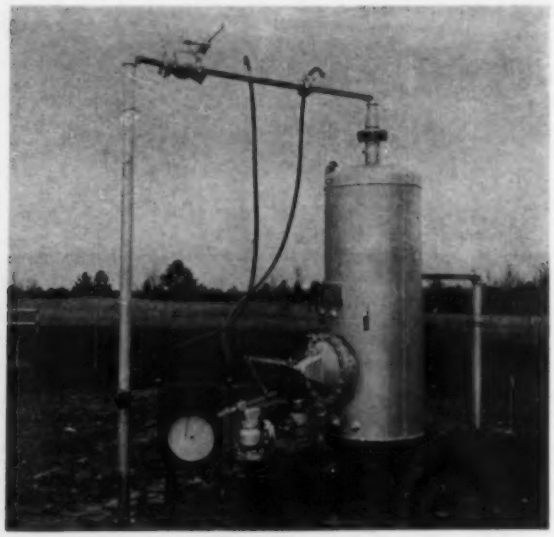
PARAFFIN INHIBITOR

This new Dowell material operates on an entirely different principle. The chemicals used do not dissolve paraffin, but are actually designed to prevent its deposition. Small amounts of the inhibitor are injected into the well periodically in the same manner as corrosion inhibitors. Careful preparation of the well is required before the treatment begins.

"FRAC GUIDE"

This Dowell collection of charts and formulas is arranged to aid in the more effective engineering of fracturing treatments. With the "Frac Guide," Dowell engineers can help you select the proper type and volume of fracturing fluids, sand sizes and quantities, injection rates and treating procedures — to give optimum results at the lowest possible cost.

Newly-equipped pumping wells are sized for efficiency and long life. During later producing life, these units are of sufficient size to handle large fluid volumes anticipated.



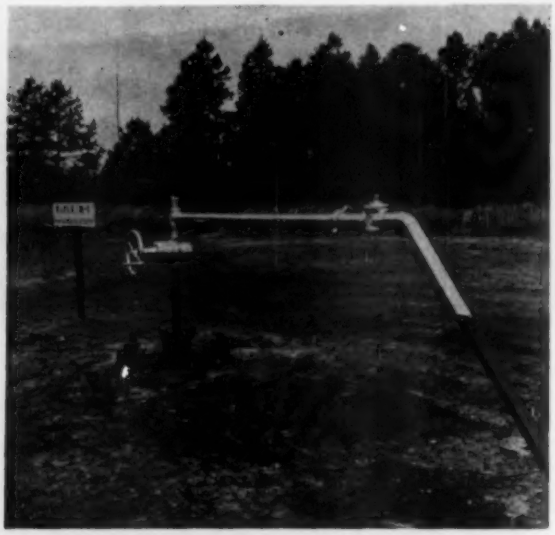
Metering hookup for each producing well contains orifice plate in gas line (connected to portable meter) and positive displacement meter between oil outlet and dump valve. Meter was so located to prevent corrosion readings due to cavitation.

was adopted. The 80-acre development pattern for the field (for each quarter section, one well was drilled center of northwest quarter and another well drilled in the center of the southeast quarter) was ideally suited to the five-spot pattern with regard to distances between injecting and producing wells for maximum sweep efficiency. Further investigation indicated some advantages existed in modifying the five-spot to a peripheral type pattern in some field areas. This modification avoided trapping oil in the tight and thin outer extremities of the productive area. Additional modification may be necessary as the flood progresses, but the flood pattern should remain basically as shown in Fig. 4.

Injection Plant and Centralized Storage

Maximum flexibility and simplicity were designed into the water injection plant and centralized storage facilities. The system is capable of handling 8800 bbl of produced fluids daily. Maximum oil storage capacity is 6000 bbl. Fig. 5 is the simplified flow diagram of the central plant facilities. Interior coating or cathodic protection is used on all vessels to combat corrosion. All vessels carry gas blankets and the entire pipeline system is sealed from the atmosphere to further restrict corrosion. Both the source and produced waters will be filtered prior to injection to prevent sandface plugging in the well bore.

Injection facilities consist of two vertical triplex plunger pumps. Each pump



Typical water injection well in the West Lisbon "A" zone Pettit lime. There are currently 13 such injection wells.

Charlie Reed, district superintendent for Spartan Drilling Company's West Lisbon Pettit Lime Unit, stands beside triplex plunger injection pump inside pump station.

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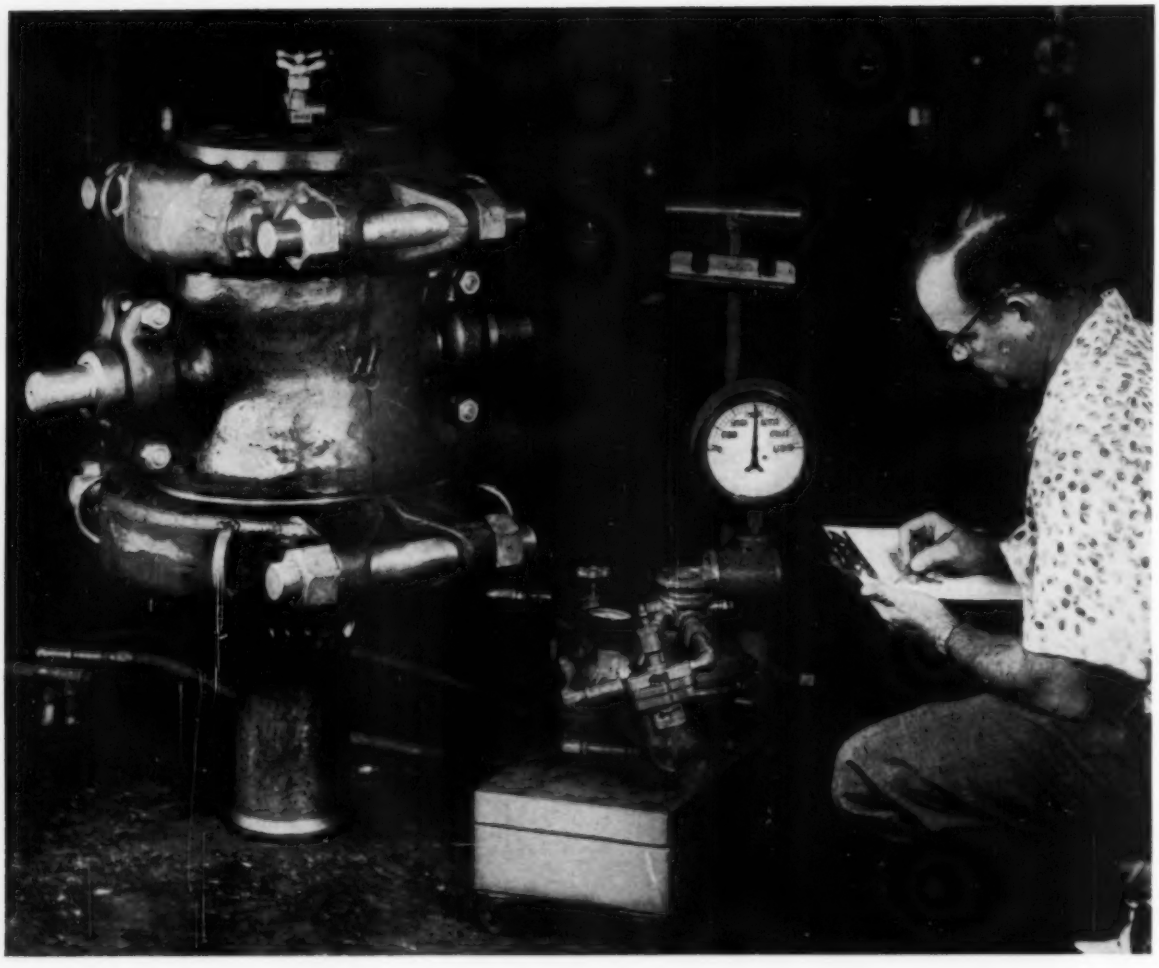

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has a capacity of 3180 bbl per day at a discharge pressure of 1880 psi. Maximum anticipated injection volume is 5600 bbl per day at an injection pressure of 1400 psi. Each pump is powered by gas-fueled reciprocating engines equipped with necessary automatic and safety control devices.

Source Water

Injection water is obtained from the Sparta sand at a total depth of 700 ft. This sand covers a very large area and is capable of supplying any amount of water needed for the flood. Information obtained from other floods using the same source water discloses that it is compatible with the produced water, occasioned by water breakthrough, from the Pettit lime. At such time as produced water enters the plant it will be commingled with the Sparta water and injected back in the Pettit lime.

Injection and Gathering Systems

Three pipeline systems radiating out from the centrally located pump station are employed in this secondary-recovery project. The injection system is designed and manifolded to provide for maximum flexibility and ease of operation. It consists of 2 to 4-in. ID, schedule 80, seamless, cement-lined pipe capable of handling corrosive waters at pressures up to 2000 psi.

The oil gathering system is made up of schedule 40, cement-lined seamless pipe varying in diameter from 2 to 5-in. ID. This corrosion resistant system transports all produced fluids to the central tank battery. The gas distribution system is comprised of 2-in. line pipe and 4½-in. used drill-pipe. This system returns fuel gas to each of the pumping unit engines from the central tank battery.

All lines are buried with a minimum 24-in. cover for protection. The injection and gathering lines are welded with gaskets inserted between the joints prior to welding. Gas lines are screwed pipe with the exception of the 4½-in. drill-pipe which was welded. Layout of the injection, gathering and gas systems is shown in Fig. 4.

Oil, Water and Gas Meters

The effluent from each well is produced through a separator removing the gas for measurement by orifice meter and allowing the use of a positive displacement meter for measurement of total fluid. A sample of the well fluid is taken daily and from a shake-out test, percentage of water and oil is determined. This method has proved to be 95 percent accurate. In addition to individual well measurement, the total oil is measured daily in the central storage tanks.

Injection water is measured by positive displacement meters at five centralized distribution points. Injection volumes and pressures are recorded daily for each of the 13 injection wells.

Make-up water for the injection system is measured daily by a positive displacement meter on the flow line of the water supply well located at the plant site.

Oil Well Pumping Equipment

A study of operating costs in other floods of this type disclosed the need for particular attention to high lifting costs which were created by the necessity of handling large volumes of fluid. Looking forward to this future need, several of the wells of high productive capacity which were predetermined to remain as producing wells after unitization, were equipped with pumping units of sufficient size to handle the anticipated volumes of fluid. The purchase of additional pumping units and tubing with sufficient capacity was included in the economics of this program and will be installed as it becomes necessary.

Participation Formula of Each Unitized Tract

Unitization of the West Lisbon Pettit lime reservoir necessitated a formula to equitably prorate the oil produced by the unit to each tract in the unit. The formula arrived at was composed of three factors weighted in proportion to their relative importance. These components are:

1. Relationship of the hydrocarbon pore space under each individual tract to the hydrocarbon pore space under the total unit.
2. The well count of each tract times the productivity of each tract with regard to total unit productivity.
3. Relationship of the remaining reservoir oil in place under each track to the remaining oil in place under the unit as of an agreed date.

All acreage containing hydrocarbons as determined by the data and maps employed was included in the unit. Hence, a number of undrilled tracts entered the unit and will participate in the recovered oil. However, since their contribution to the unit will not be as great as the drilled tracts, the formula adjusts for this by a well count factor in the second part of the formula.★ ★

About the Authors

Frank H. Miller, *chief engineer for Spartan Drilling Company of Dallas, Texas, graduated from the University of Texas with a BS degree in Petroleum Engineering in 1939. That same year, he became associated with the Lisbon Exploration Company of Shreveport. In March, 1940, he joined the H. W. Klein and Grady H. Vaughn interests as a petroleum engineer in the Lisbon field. He served as an officer in the U. S. Corps of Engineers from 1942 until 1946 and returned to his duties with H. W. Klein as superintendent in charge of field operations in Texas, Arkansas, Louisiana and Oklahoma. In 1955, he was transferred to the home office of the Vaughn interests in Dallas as chief engineer of Spartan.*

Al Perkins *is assistant chief engineer for Spartan Drilling Company, a post he assumed in January, 1960, after serving as district superintendent for Spartan in the West Lisbon Unit. He received his BS degree in Petroleum Engineering from Texas A&M College in 1954, and immediately joined Spartan as a field engineer in South Texas. Since that time he has served in Arkansas, in Cuba as superintendent of operations for Cuban American Drilling & Exploration Company, and in various engineering capacities in North Dakota, Canada, West Texas, Arkansas and Louisiana.*

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Log Evaluation at the Well

Principal interpretation methods used today with electrical logs point out applications for field uses in quantitative evaluation of pay zones

R. P. Alger
Schlumberger Well Surveying Corporation
Houston, Texas

WHY SHOULD LOG EVALUATION be done at the well? Some might say that there is no place for it in the field—that the logs should be sent to an expert, where correction curves, interpretation charts, and a contemplative atmosphere are all available. While it is true that the most accurate quantitative results are not expected from field interpretation, qualitative or semiquantitative work is desirable.

Here are a few reasons for this:

1. Favorable zones are located which can be further examined by sidewall cores, formation tester, or drill stem test.
2. Often an attempted interpretation points to the lack of certain information, which can be obtained through additional logs. The time to get this information is before plugging or setting casing.
3. Errors in logging, scales, mud information, and the like can often be recognized when interpretations are attempted.
4. Time is always a factor, whether considering rig time or lease plays.
5. The more people who study the set of logs, the less chance of missing an oil sand.
6. The man at the well should have a feel for the interpretation, if he has observed the drilling of the well. Also, he is in a good position to consult various types of drilling logs and get opinions from the logging engineer.

We shall present the background for quantitative interpretation and developed the principal interpretation methods which are used today. For each, applications for field use are pointed out. In the following, the term "oil zone" can also mean "gas zone," since in most cases oil and gas produce about the same effects on the logs being considered.

Fundamentals of Oil-Finding Techniques

Significance of resistivity in water-bearing rocks. Since matrix materials are practically nonconductive ($R = \infty$), electrical current is conducted primarily by water in the pores of the rock. The higher the salinity of the water, the more conductive it is. This makes the resistivity of the rock lower. Thus, it is evident that we need to know what kind of water is present. This quality is described by R_w, the water resistivity. Also, the more water present, the more conductive the rock. This, then, requires knowledge of the pore space: i.e, porosity.

Finally, the resistivity (R_o) of the water-saturated rock will be directly proportional to the fluid resistivity (R_w) and inversely proportional to the porosity (ϕ).

Mathematically we may write

$$R_o = \frac{a\,R_w}{\phi^m}, \quad \ldots \quad 1a$$

where "a" is a coefficient which may vary from 0.62 to 1.0 and "m" an exponent which may vary from 1.3 to as much as 2.5. An easier way to describe the relations between the water resistivity and the formation resistivity is to say

$$R_o = F\,R_w. \quad \ldots \quad 1b$$

F, the resistivity formation factor, is thus a direct function of porosity, such that $F = a/\phi^m$.

Significance of resistivity in oil-bearing rocks. When oil is added to a porous rock, there is a reduction in the amount of water available to carry current, so the formation resistivity increases. However, there is always some water present to conduct the current. This amount of water, given as a fraction of the pore space, is designated S_w. The true resistivity (R_t) of such a rock will now be

$$R_t = \frac{a\,R_w}{\phi^m\,S_w^n} \quad \ldots \quad 2a$$

or

$$R_t = \frac{F\,R_w}{S_w^n}, \quad \ldots \quad 2b$$

and "n" normally equals 2. Note that R_o is a special case of R_t, where $S_w = 1$. Since we try to measure R_t directly, if we also know R_w and ϕ or F, we can solve for S_w: i.e.,

$$S_w = \left(\frac{a\,R_w}{\phi^m\,R_t}\right)^{1/n} \quad \ldots \quad 3a$$

or

$$S_w = \left(\frac{F\,R_w}{R_t}\right)^{1/n} \quad \ldots \quad 3b$$

This last relationship is usually called the Archie equation. For production, S_w should generally be under 0.50; but this value is dependent on the pore structure of the rock. Consequently, the critical S_w (i.e., the upper limit of S_w for oil production) can be from

0.35 to 0.70, depending on porosity and

over 50, the deep investigation induc-

a calculation of R_o for any particular

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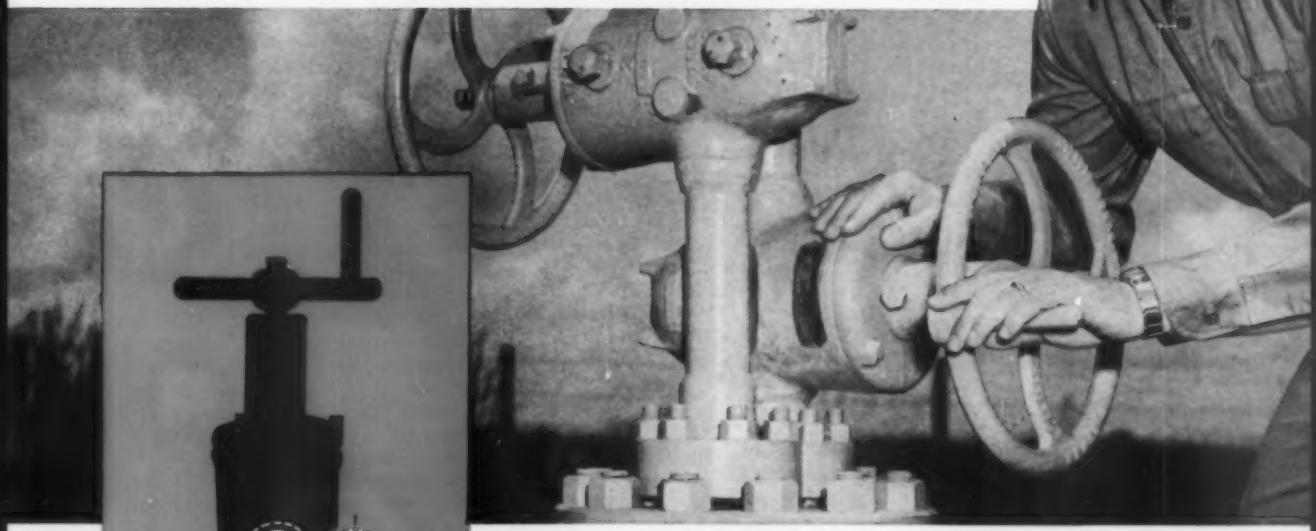

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0.35 to 0.70, depending on porosity and permeability characteristics.

Direct method for saturation determination. If we compare the resistivity of a water-bearing and an oil-bearing rock of the some porosity and type of connate-water, we can see directly the effect of the oil. By dividing Equation 2a by 1a or Equation 2b by 1b, we find that

$$R_t/R_o = 1/S_w^n. \quad . \quad . \quad . \quad 4$$

This relation provides the simplest method for field log analysis, since only two resistivity values are required.

Many people do not compute S_w but look at the ratio R_t/R_o only, which is called the resistivity index (I). When the index exceeds a certain value, usually chosen by experience, the zone becomes worth testing.

Water saturation and resistivity indexes are usually related as follows: $S_w = \sqrt{1/I}$ or $S_w = \sqrt{R_o/R_t}$.

$R_t/R_o = I$	S_w
1.0	1.0
2.0	0.70
3.0	0.57
4.0	0.50
5.0	0.45
8.0	0.35

For a good determination of the resistivity index or S_w, reliable values of resistivity must be available.

R_t from logs. The best R_t for all interpretations, and especially for field work, will come from a curve which requires no correction for the borehole, bed thickness, or invasion. Departure curves, except for the simplest corrections, are dangerous to use except in the hands of an expert. Thus, for field use it is vital to know which curves to trust and to have those curves recorded in the well of interest.

The higher the porosity, the easier it is to measure R_t. This is because invasion is shallower and its value is comparatively low. For high porosity, as shown on logs by $R_{16\text{ in.}}/R_m < 10$, R_t may be taken from either the induction or the 64-in. normal, if the bed is thick enough. For the induction, a 5 ft bed thickness is sufficient. The 64-in. normal will be close to R_t in a 20 ft bed; beds between 10 ft and 20 ft thick can provide a corrected R_t by simple rules of thumb.

For medium porosity, shown on logs by $R_{16\text{ in.}}/R_m$ ranging between 10 and 50, R_t is satisfactory from the induction except for rare cases of deep invasion; the 64-in. normal is not very trustworthy unless the zone is known by other means to carry oil; the lateral is good if the bed is thick.

For low porosity, $R_{16\text{ in.}}/R_m$ being over 50, the deep investigation induction or the lateral curve (after correction) is best to measure R_t. However, in some cases, such as deeply invaded water zones, no device is capable of giving a value close to R_t.

For wells drilled with salty mud, and with medium to low porosity, a laterolog is essential for obtaining R_t. It is well to remember that in water-bearing zones it will give values close to R_t (i.e., R_o). It may give values below R_t when the zone is oil-bearing since invasion may have flushed some oil from the formation close to the hole.

Field Interpretation for High Porosity Formations

Water zone below oil pay. In general, where the resistivity drops to a constant low value in the lower part of a highly porous zone, a definite indication of a water contact is shown. The ratio R_t/R_o is then available since the variation in F is usually relatively small in such a sand and R_w is expected to be constant.

As a safety measure, it is well to use a porosity tool to assure that qualitatively the porosity is unchanged throughout the zone. This may be done by looking at a sonic log or a microlog to see if the curve maintains about the same level. If these devices show lower porosity where the resistivity is high, the higher resistivity is attributable to to the higher formation factor rather than the likelihood of oil. If the porosity is higher, the water saturation may be lower than the resistivity ratio indicates.

Sometimes, with little invasion, the microlog is influenced by the high oil saturation and the porosity appears low opposite the high resistivity. Such a zone should be checked by a sonic log which gives an optimistic instead of a pessimistic value of porosity where only limited flushing of the oil has occurred. In high porosity regions, all high resistivity zones must be carefully double-checked.

Comparison with adjacent sands. R_w is fairly constant for sands in the same formation. If porosity is not too variable, resistivity comparisons of obvious water zones to zones of higher resistivity may be significant.

If it is desired to correct an apparent resistivity index, or S_w, by applying porosity information, we can write

$$I = \frac{F(\text{water})}{F(\text{oil})} \times \frac{R_t}{R_o};$$

$$S_w \simeq \frac{\phi \text{ in water}}{\phi \text{ in oil}} \sqrt{R_o/R_t}.$$

Comparison with reconstructed water zone resistivity. Knowledge of porosity and an R_w catalog will permit a calculation of R_o for any particular sand; this is then compared to the R_t of the sand. It is advisable where possible, that R_o for the zone or zones of interest be estimated before the logs are run. These values are then drawn on the log to give a visual method of looking for pays.

All the above methods imply that the porosity keeps rather constant. Such conditions occur mostly in high porosity (unconsolidated) regions. The greater the consolidation, the more dangerous the use of these approaches becomes.

Furthermore, shaliness can be very troublesome and special features must be used to find oil in shaly sands.

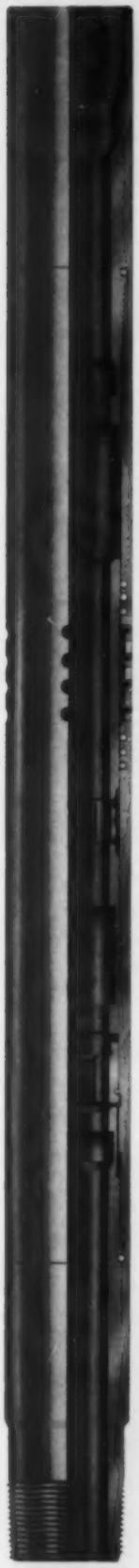
Shaly sands. Qualitative interpretation in shaly sands is both difficult and dangerous. Shaliness is recognized by lowered SP peaks. Still more SP reduction occurs when oil is present. A low SP, then, is frequently the best visual clue to the presence of oil. Any zone which shows only a very small increase in resistivity must be suspected and checked with sidewall samples. A rather rapid evaluation of unconsolidated sands and shaly sands is possible by assistance from the sonic log, using a method shown as *Fig. 1*. This method computes an R_w value, assuming all zones are water-bearing. If oil-bearing, the apparent R_{wa} is definitely above the other values.

The theoretical advantage of this method is that the porosity variable is eliminated. Also, for shaly oil sands, the effects of shaliness on the resistivity and the sonic log compensate each other (R_t is lowered and apparent porosity increased). The ratio R_{wa}/R_w may be considered equal to the resistivity index. Values of the ratio required for production are at least 2 for shaly oil sands and at least 3 for clean oil sands.

It may be stated that absolute values of R_w are not essential (due to possible errors in assessing the compaction correction for the sonic porosity); and that the ratios will tell the story.

Field Interpretation for Medium Porosity Formations

As mentioned before, good values of R_t are more difficult to obtain in lower porosity, especially in water zones. Oil zones do not present much difficulty. Therefore, of the methods for high porosity in which R_t is compared with R_o, only the one where a reconstituted R_o is used for comparison is very reliable. Furthermore, the porosity may not remain constant; thus, either a porosity log should be obtained and evaluated or some other approach is required. Such a method will be discussed briefly.



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Invaded zone methods and application. If resistivity measurements of widely varying investigations are made, saturation can be quantitavely determined if the following are known:

1. The relative investigation of each device.
2. The ratio of the average resistivity of the waters existing in the portion of rock being investigated by each device. This ratio is directly related to the SP, so the SP will usually be used instead of this ratio.
3. An idea of the saturation relations between the flushed (or invaded) and unflushed zones. (Water saturation in the flushed zone is termed S_{xo} and in the invaded zone S_t.)
4. A rough idea of invasion depth.

Required, then, are two resistivity readings taken at the level of interest and a value for the SP or its equivalent R_{mf}/R_w. No prior kriowledge of porosity is required. Charts are available, based on the ratio of the readings of a deep and a shallow investigation device, for several resistivity-log combinations as listed in the following table:

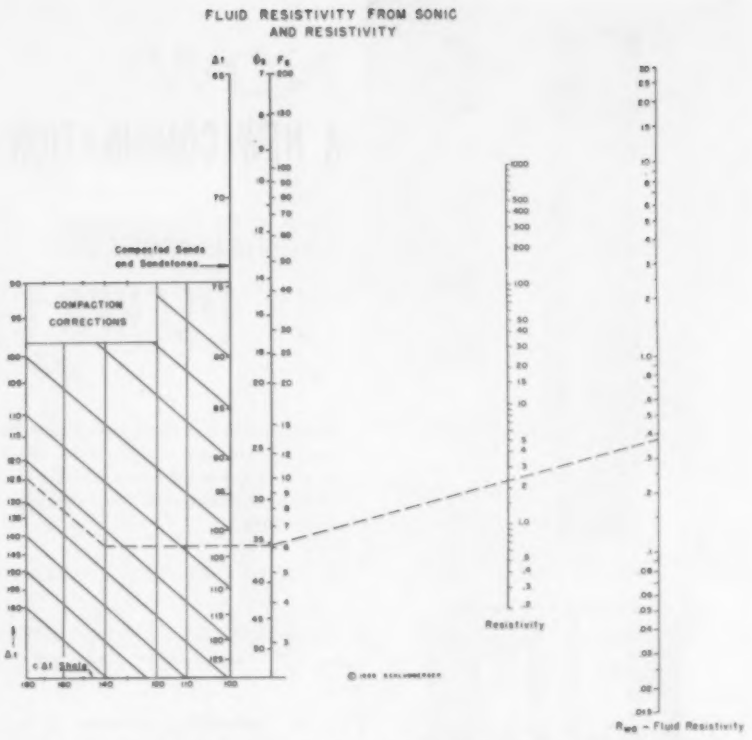


FIG. 1. Rapid evaluation of unconsolidated sands and shaly sands is possible with assistance from the sonic log.

Ratio Derived From	Invasion Model: Invasion Limits	Saturation Relations	Interpretation Chart
1. Lateral + Short Normal	4 to 8d	$S_t^2 = S_w$	Fig. 2
2. 5FF40 IL + Short Normal	2 to 10d ($R_{xo} > R_t$)	$S_{xo}^5 = S_w$	Fig. 3
3. 6FF40 IL + Short Normal	2 to 20d	$S_{xo}^5 = S_w$	Fig. 4
4. R_t (from any source) + R_{xo}		$S_{xo}^5 = S_w$	D-4[1]

Once S_w is obtained, porosity can be computed by rewriting the formula

$$S_w^2 = \frac{F R_w}{R_t} \text{ as } F = \frac{R_t S_w^2}{R_w},$$

and relating F to ϕ by standard relations. If such ϕ value is correct, both the S_w obtained and the R_t value used should be correct. If, however, the invasion model for the combination was not correct, the computed porosity will be wrong. To check this, an independent reliable porosity is recommended.

This procedure, called the porosity balance, is rather involved for field evaluations. In some cases, however, it is vital, since, if the balance is not obtained, the interpretation is usually reversed.

Use of lateral + short normal. Zones are selected where the bed is sufficiently uniform and thick enough to get good values. In general, the minimum thickness is about 25 ft if resistivity contrasts are appreciable. The values from each device are then corrected by simple departure curves. The normal is corrected for borehole only and the lateral for borehole and average invasion. Usually the apparent resistivity values from the two devices are corrected to increase the normal and decrease the lateral.

When a field interpretation is to be made, the first thing is to note the SP magnitude (or R_m/R_w ratio if R_w is known) and refer to *Fig. 2* to find the approximate R_i/R_t ratio for a certain critical S_w.

For example, for sandstones we may not be interested unless the S_w is under 0.50. If the SP deflection for a zone equals −50 mv, *Fig. 2* shows that the R_i/R_t ratio should not exceed 1.5. On the log, the ratio of apparent resistivities will be somewhat different since the lateral reads about ⅓ too high while the normal which although sensitive to the borehole diameter, is nearly correct in an 8 in. hole. Thus, the short normal must not be much higher than the lateral when looking for zones of interest in medium porosity formations.

Below is a brief table showing apparent log ratios for different SP values to use for field interpretation. Oil zones will give $R_{16\,in.}/R_{Lat}$ ratios smaller than shown below.

For $10 < R_{16\,in.}/R_m < 50$, d ≈ 8 in., $S_w = 0.50$.

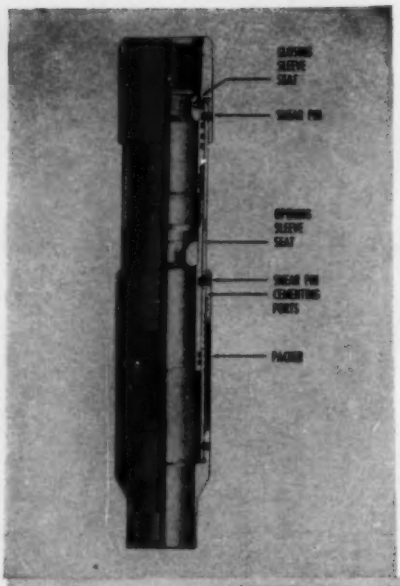
SP	R_m/R_w	R_i/R_t[1]	$R_{16\,in.}/R_{Lat}$[1]
0	1	0.5	< 1.0[2]
− 30	2.2	1.0	≃ 1.0[2]
− 50	3.6	1.5	1.1
− 70	6	2.2	1.6
− 90	10	3.0	2.2
− 110	16	3.9	2.9
− 140	35	5.2	3.9

Note:

1. For $S_w = 1.00$, the ratios will be double those shown above.
   For $S_w = 0.35$, the ratios will be 0.7 times those shown above.
2. For low SP, the investigation of the 16 in. normal is increased, so that it no longer is an R_t tool. A microlaterolog or proximity log would give values closer to R_t.

If the resistivity values are appreciably higher than 50 R_m, corrections become more significant and must be

[1] In Schlumberger Log Interpretation Charts Handbook.



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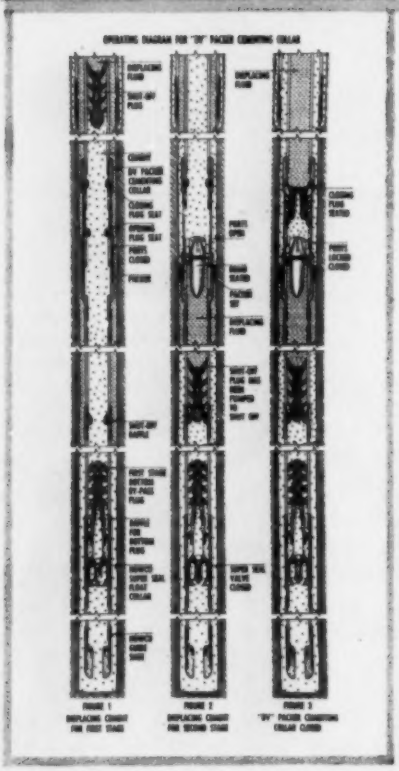

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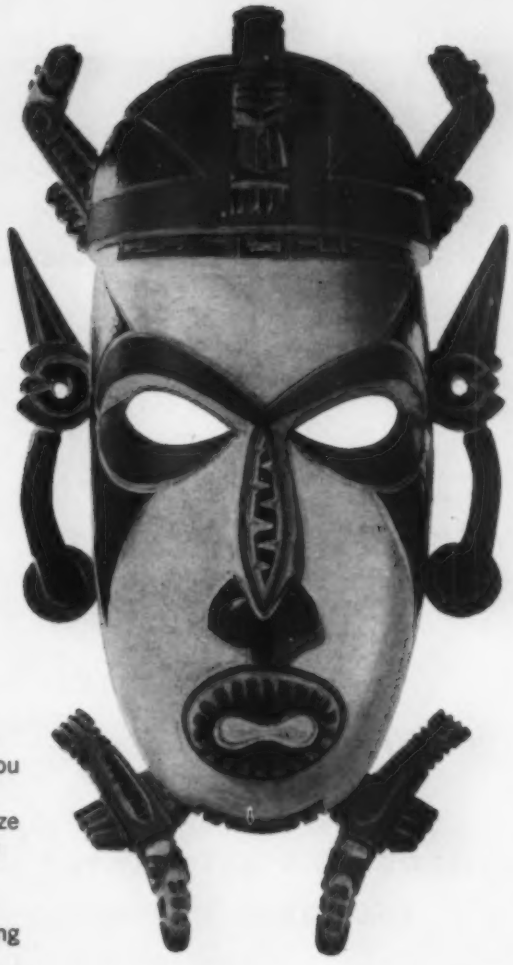

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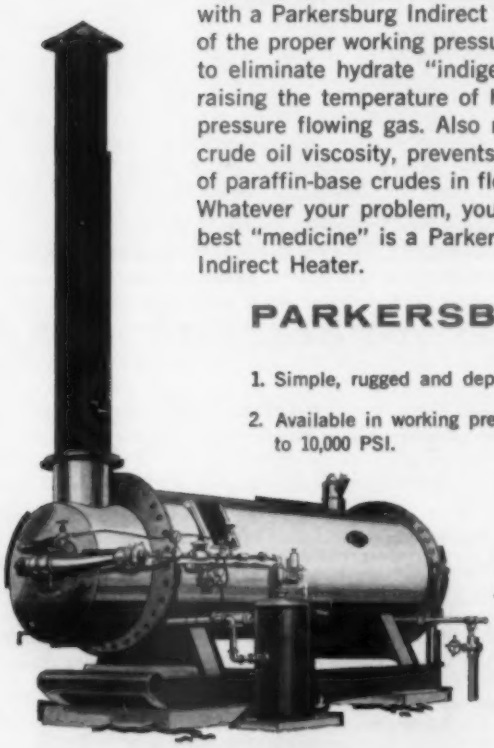

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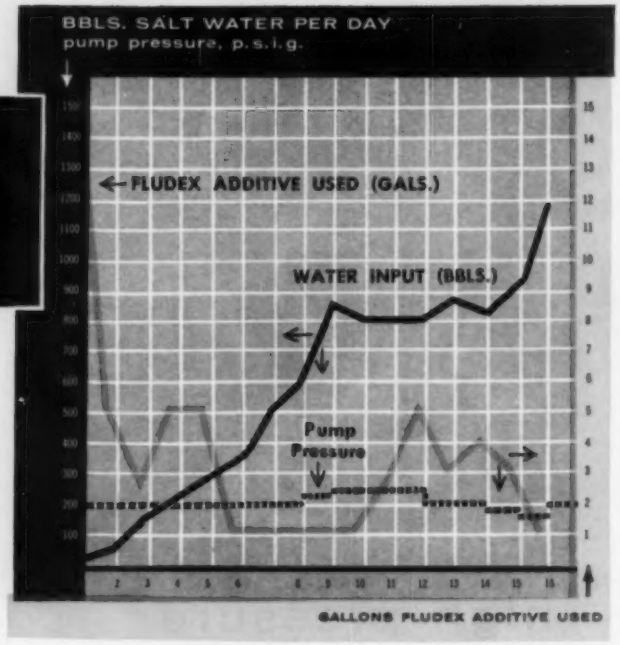

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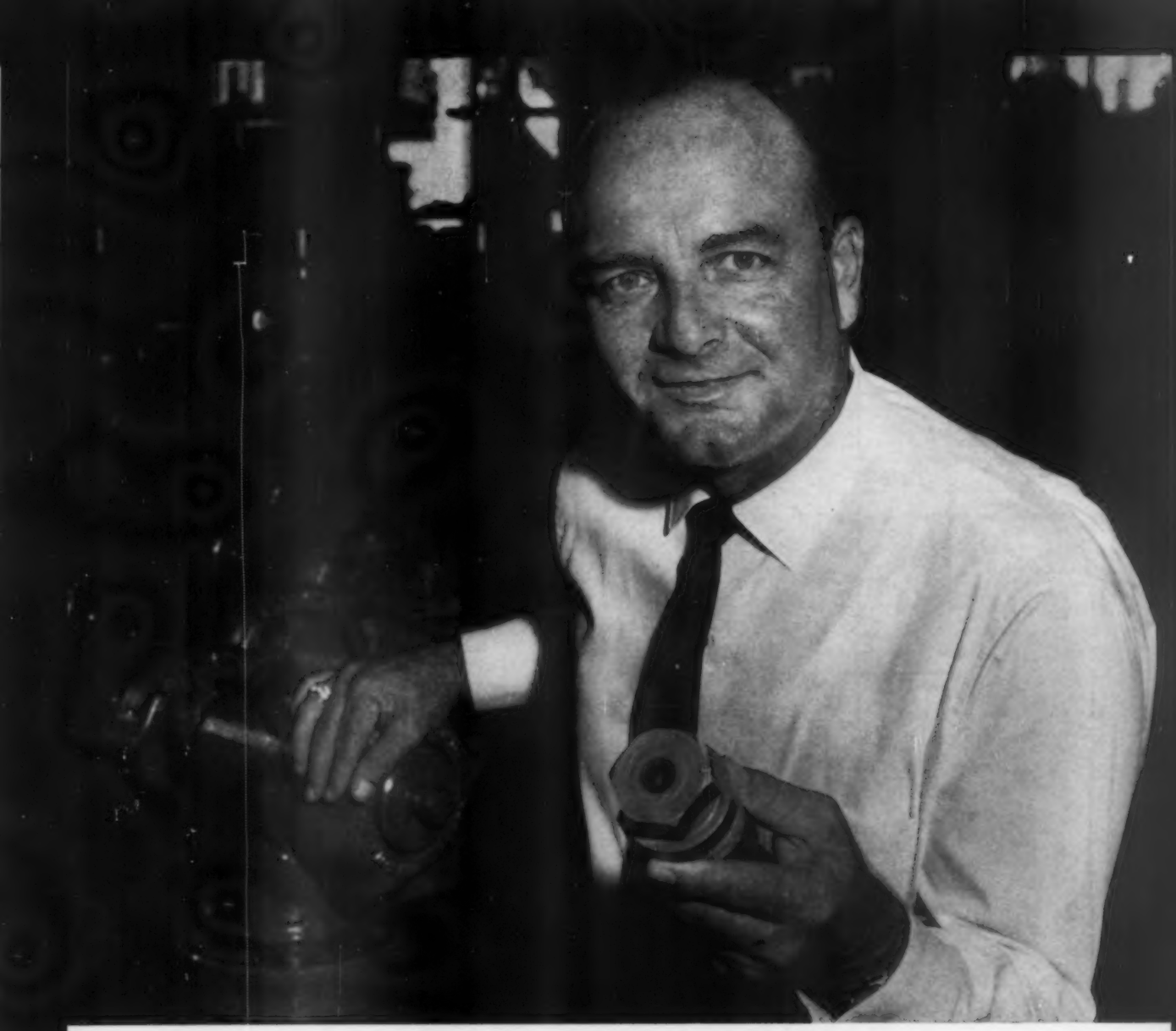

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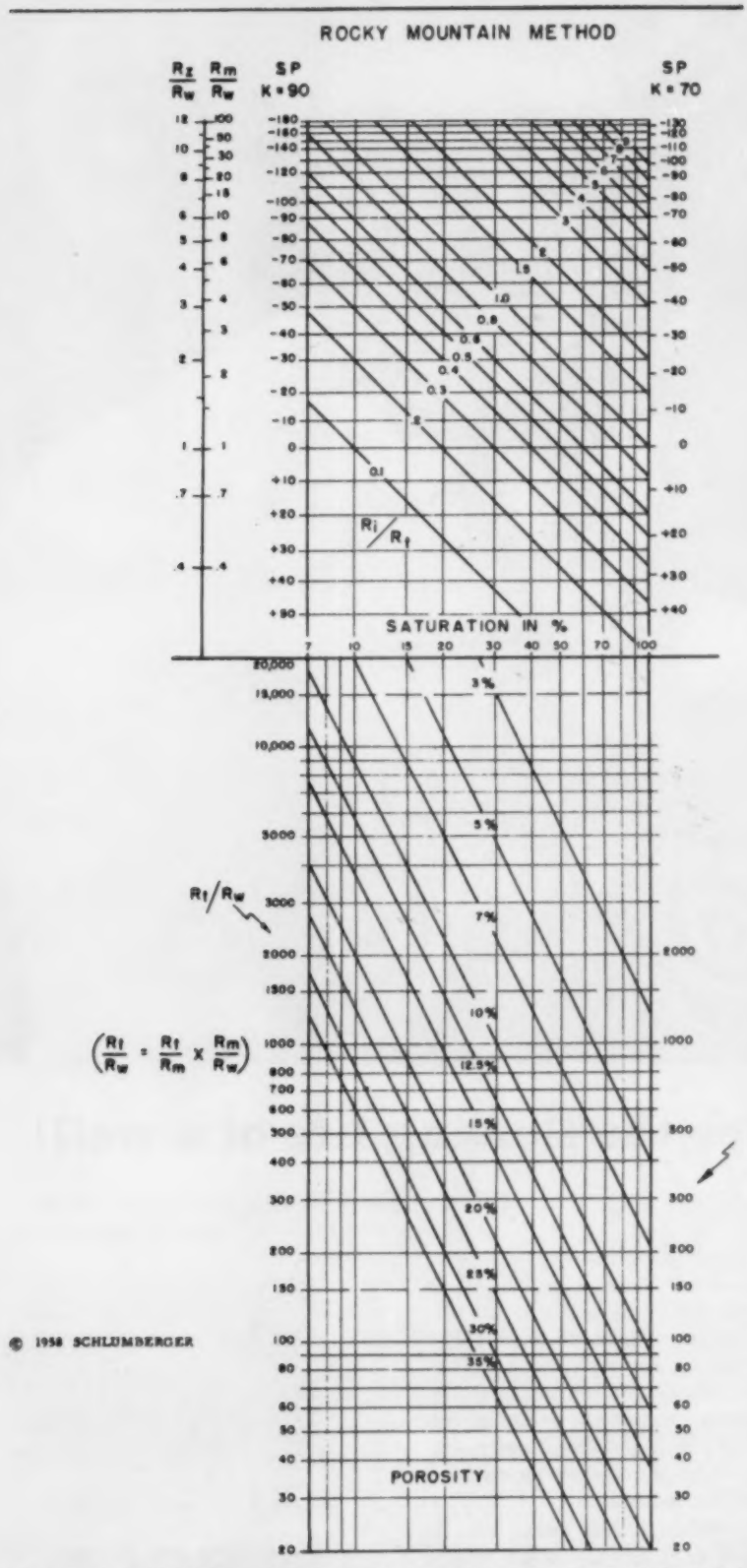

FIG. 2. First step in field interpretation is to note SP magnitude, then refer to chart and find approximate R_i/R_t ratio for a certain critical Sw.

determined from *Fig. 5* to obtain the correct R_i/R_t ratio. It is good practice to always use this chart since the hole size corrections may also be important.

Induction logs. When an induction log is used as the deep investigation device, *Fig. 3* (or its companion chart for 6FF40 induction, *Fig. 4*) is recommended. Again, a critical resistivity can be found for a selected S_w value and the SP (or R_{mf}/R_w) of the zone in question. For proper evaluation by this method, the bed thickness need only be 6 ft or more, whereas the lateral requires at least 24 ft. Also, the induction values rarely require correction for the borehole.

Field Interpretation for Low Porosity Formations

Fresh mud wells. When $R_{16\,in.}/R_m > 50$, conditions are poor for measuring R_t with conventional resistivity devices. Therefore, we do not recommend field study of conventional logs. Instead, focused logs should be run if a field evaluation is to be made. Also, reliable porosity tools, such as sonic or neutron logs, must be run. Likewise, devices indicating permeability (micro-log-caliper) are very helpful since many zones are often found to be exceedingly dense and of no interest.

The SP is also helpful in locating permeable zones, but it is greatly distorted by intervening dense zones. Sometimes good SP deflections occur where hydraulic permeability is exceedingly low.

The lithology of reservoir rocks of low porosity is frequently limestone or dolomite plus additional impurities such as chert, disseminated siliceous material, anhydrite, and gypsum. These, plus the wide range in pore structure typical of carbonates, make interpretation in such complex rocks exceedingly difficult. Porosity can vary rapidly, and F and thus R_o will vary about twice as fast. The R_o for a zone can have a wide range of values, both vertically and horizontally.

Visually, the logs of sandstone pays and carbonate pays are somewhat dissimilar, reflecting the differences in pore structure; thus, they should be treated separately. Consequently, prior knowledge of lithology (from cuttings, for example) is useful before a field evaluation is begun.

Sandstones of low porosity. In this class of formation, the porosity of the sandstones will be less than 15 percent. Matrix permeability sufficient for oil production without fracturing usually vanishes at about 10 percent porosity although gas or condensate can be produced to around 8 percent porosity. Of course, in these cases fracturing will usually be necessary to provide com-

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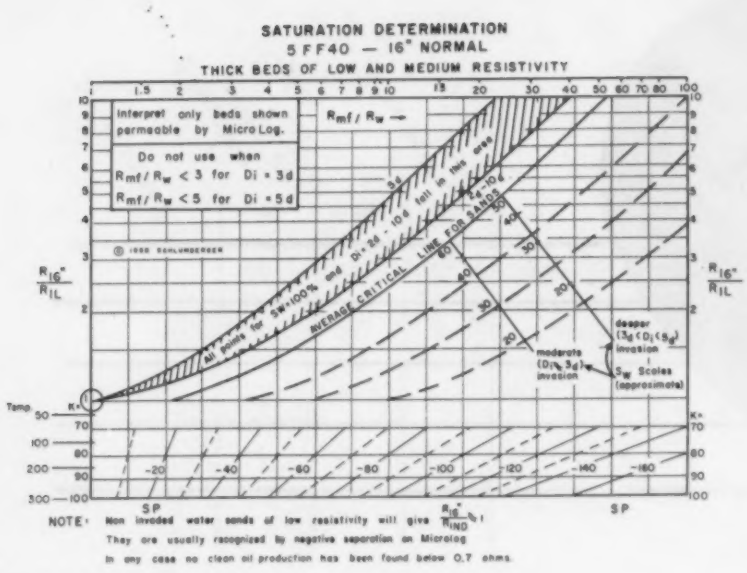
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AVERAGE CRITICAL LINE FOR SANDS
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Sw Scales (approximate)
Temp.
SP
NOTE: Non invaded water sands of low resistivity will give
They are usually recognized by negative separation on Microlog
In any case no clean oil production has been found below 0.7 ohms.

FIG. 3. Induction logging chart.

mercial flow rates, but even this will be of little help in porosities of less than 8 percent.

From a logging point of view, a microlog will show mud cake down to about the 10 percent porosity and very little or no mud cake below this value. Similarly, water sands with porosities of more than 10 percent usually invade very deeply, while the tighter sands may not have sufficient permeability to invade at all.

Porosity data for such sandstones are very helpful. The microlaterolog or proximity log can help only when sufficient invasion has occurred. The recommended method uses the sonic log, which gives practically the same results whether invaded or not. For such formations, conversion from Δt to ϕ requires V_m to be from 18,000 ft per sec to 19,000 ft per sec.

Critical Δt Values For Sandstones

	$\phi = 10\%$	$\phi = 8\%$
$V_m = 18000$	69	66.3
$V_m = 19000$	66	63.3

Recommended means of obtaining R_t depend a good deal on the R_w values. When these values are low, so that $R_m/R_w > 5$ to 10, the true resistivity is usually not too high and the induction tool is recommended. If R_w is fairly close to R_m (this being a moderate value, as in fresh muds), the true resistivities tend to be high, in which case the laterolog is preferred.

For sandstones, first look for permeable zones as shown by the microlog. Use a sonic log for porosity control. A blank chart, as shown by *Fig. 6*, is used to plot Δt vs R_{IL} or R_{LL}.

In using *Fig. 6*, an appropriate range of Δt values is placed on the abscissa. Now, points are plotted for the Δt and the resistivity from as many zones as possible within the same geologic unit. Points where R_o is read will fall on a NE-SW trend, and a straight line is drawn through them and labeled 100 percent water. If experience has shown that the critical resistivity index is 3, another line whose ordinates are 3 times the upper line is drawn. Points below this line indicate probable pay.*

Invaded zone methods, described under medium porosity formations, can also be used in thick beds if the resistivity curves are properly corrected and the S_w and R_t values are verified by the porosity balance technique. However, this work is not recommended at the well site.

Carbonates. The appearance of logs in carbonate rocks is unusual because pay zones are not often found where R_t is highest. In fact, sometimes the lowest resistivity turns out to be the pay. This is because the nonpay may be dense, with a porosity of only 1 or 2 percent, so that its F can be several hundred times that of the pay. Of course, low resistivity may also be partly due to lack of oil in porous streaks.

To identify the oil-bearing streaks is not very easy. The sonic-R_{IL} plotting method helps, in that the best looking zones can be found. However, their higher resistivity might be due to extremely deep invasion, which is characteristic of many limestones.

Limestones with a chalky type of matrix can show very high water saturations and still be commercial. Usually their permeability is very low, and invasion may be quite shallow. Such formations have rather high porosity and low resistivity. Resistivity indexes are as low as 2 to 3. The sonic-resistivity

*For more details on this important technique see "New Developments in Induction and Sonic Logging," by M. P. Tixier, R. P. Alger, and D. R. Tanguy. (Presented at SPE Meeting in Dallas, October 1959.)

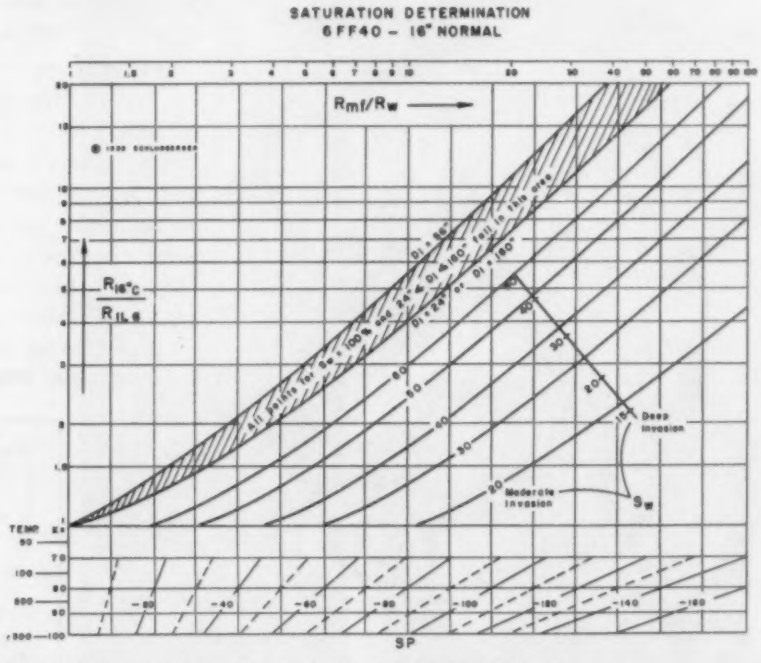
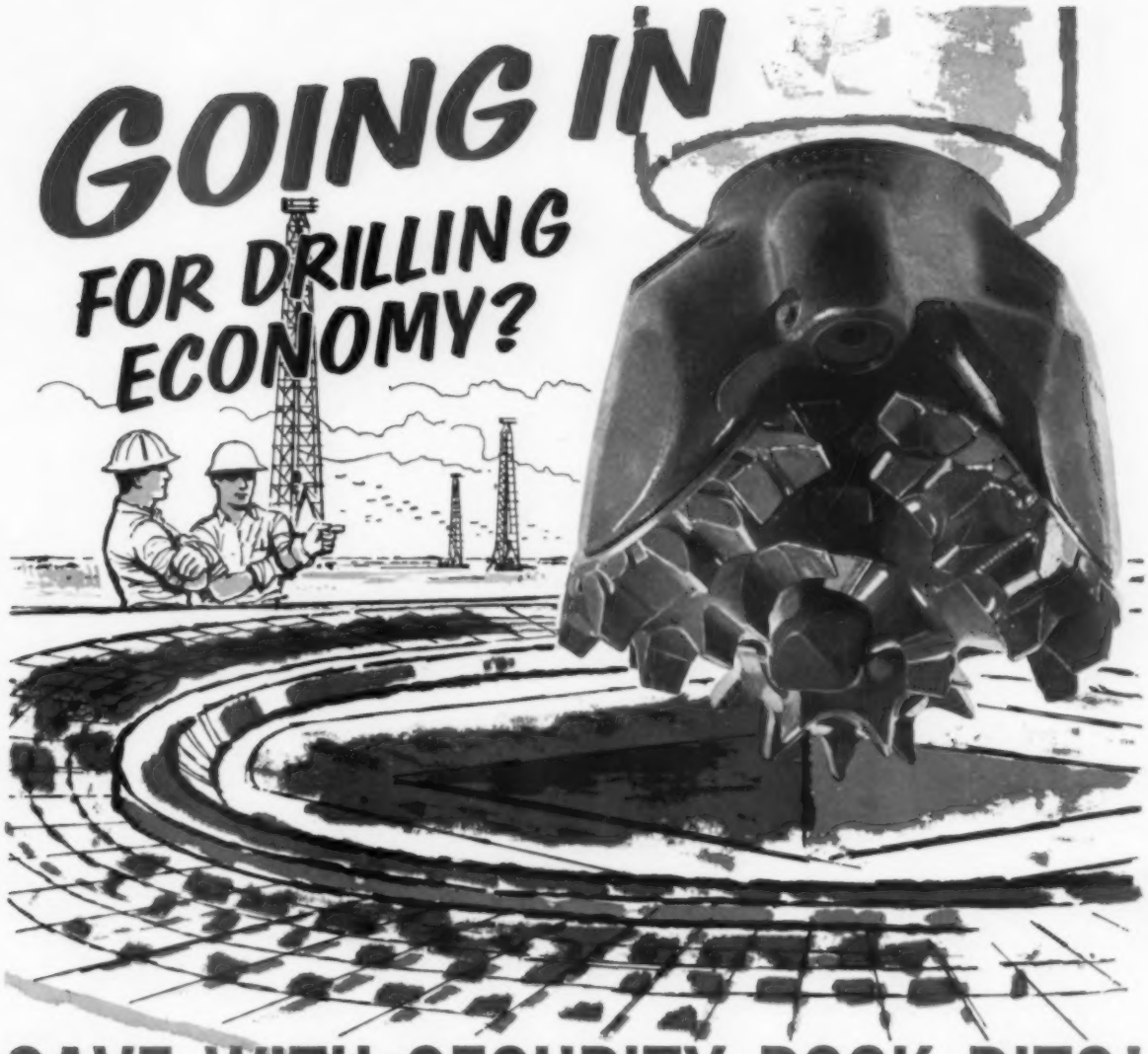


FIG. 4. Induction logging chart used with deep investigation tool.



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plotting method works quite well, but care is required since small changes in log values are significant. Identification of this type of rock must precede log interpretation.

Salt mud wells. In some respects, salt mud interpretation can be easier than fresh mud interpretation if the proper tools have been run and supplementary data, such as R_w, are known. A gamma ray is essential to locate shaly beds. Identification of permeable zones is not easy but may be often surmised if a microlaterolog is also used with the laterolog. Invasion (and thus permeability) is proved when $R_{MLL} \neq R_{LL}$, and in certain cases $R_{MLL} = R_{LL}$ where invasion has occurred. Examples of this are the water zones when $R_{mf} = R_w$ and sometimes in oil zones when $R_{mf}/R_w \simeq 5$.

Two standard methods of interpretation are suggested, namely the sonic-laterolog plot and the resistivity comparison.

In the sonic-laterolog plot it is assumed that R_w and lithology are relatively constant over a geologic unit. Since $R_m \simeq R_w$, establishing an R_o line is accurate if 100 percent water-bearing zones exist. Often, a trend is found which corresponds to a 2 R_o line because those points are at residual oil saturation (depleted zones).

As for resistivity comparison, one of the oldest salt mud interpretation methods depends on comparing the laterolog with the microlaterolog. The former is assumed to read a mixture of R_t and R_i, while the latter ideally reads R_{xo}. Interpretation rules can be summarized as follows:

1. $R_{mf} \simeq R_w$
   Water: $R_{LL}/R_{MLL} = 1$
   Oil: $R_{LL}/R_{MLL} > 2$ to 3
2. $R_{mf} \neq R_w$ (but ratio not over 5)
   Water: $R_{LL}/R_{MLL} \simeq R_w/R_{mf}$
   Oil:
   $R_{LL}/R_{MLL} \gtrsim (2 \text{ to } 3)\ R_w/R_{mf}$

Thus, when ratios for many zones are found, the pay zone will show up by a ratio which is two or more times as great as those of the nonpay. These rules apply for moderate invasion. When the invasion is deep, lower ratios are significant.

Fig. 7 shows resistivity comparison curves which were empirically derived for two fields. Such charts are helpful for choosing productive zones in development wells.

It must be remembered that the microlaterolog may not always indicate a true flushed zone value because:

1. When the mud cake is thick (over ¼ in.), the recorded value is too low. Other logs are now available for R_{xo} readings through thicker mud cakes.
2. Flushing may not always be efficient, so that in oil sands the recorded value will be higher than the usual R_{xo} value which is obtained after efficient flushing.

To recognize this difficulty, an independent porosity tool is required, such as the sonic or neutron device. It is for these reasons that the sonic-laterolog interpretation is preferred.

Special Methods

Gradients. One of the quickest ways to see evidence of pay on logs is to watch for gradients. In fact, the log should be inspected for this feature before anything else.

Whenever the water table is approached in a reservoir of constant formation factor, there is, over the transition zone from oil to water, a gradual change in water saturation with depth. This affects the true resistivity of that zone in such a way that R_t varies approximately linearly with depth over the transition zone. On the SP a similar gradient may also be evident. It has a tendency to parallel the resistivity gradient, giving the closest approach to static SP at the water level. In some cases, the SP gradient is more apparent than the resistivity gradient, especially in broken limestone reservoirs.

We must realize that there are other factors besides oil saturation which can produce a gradient also.

Shaliness, decreasing with depth in sandstones is one cause. When the shale resistivity is higher than the R_o of the clean sand, resistivity and SP gradients appear. These are similar to saturation gradients in somewhat shaly zones. If the resistivity in the shaly sand is less than that of the shale, the zone is usually water-bearing.

Shaliness, increasing with depth in limestones and hard sandstones can produce a good looking resistivity gradient, but the SP gradient is reversed and opposite in trend to that of the resistivity.

Connate water, increasing in salinity

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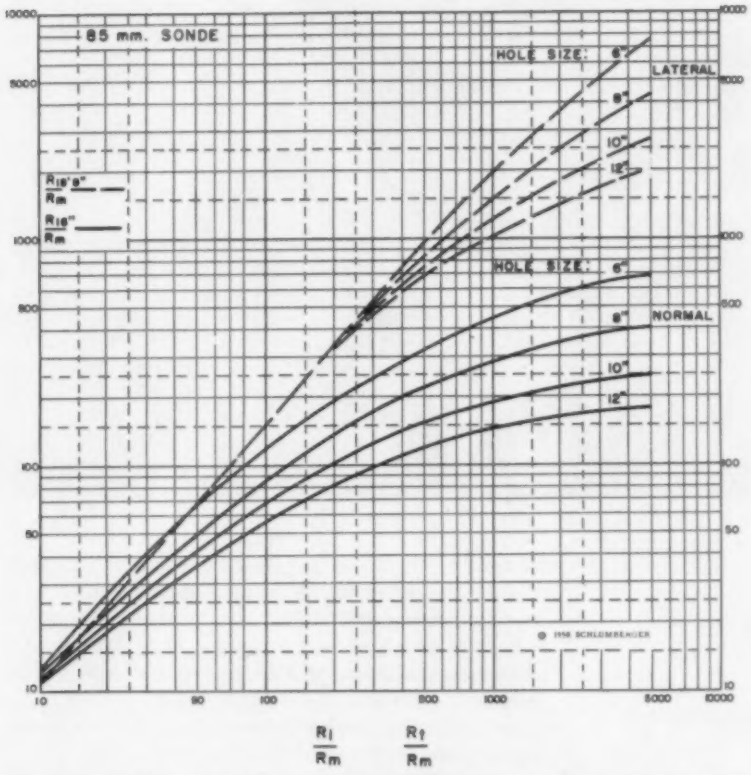

FIG. 5. In applying invaded methods, zones are selected where the bed is sufficiently uniform and thick enough to get good values. Lateral and short normal values are taken and then corrected by simple departure curves to obtain good estimate of R_i and R_t.

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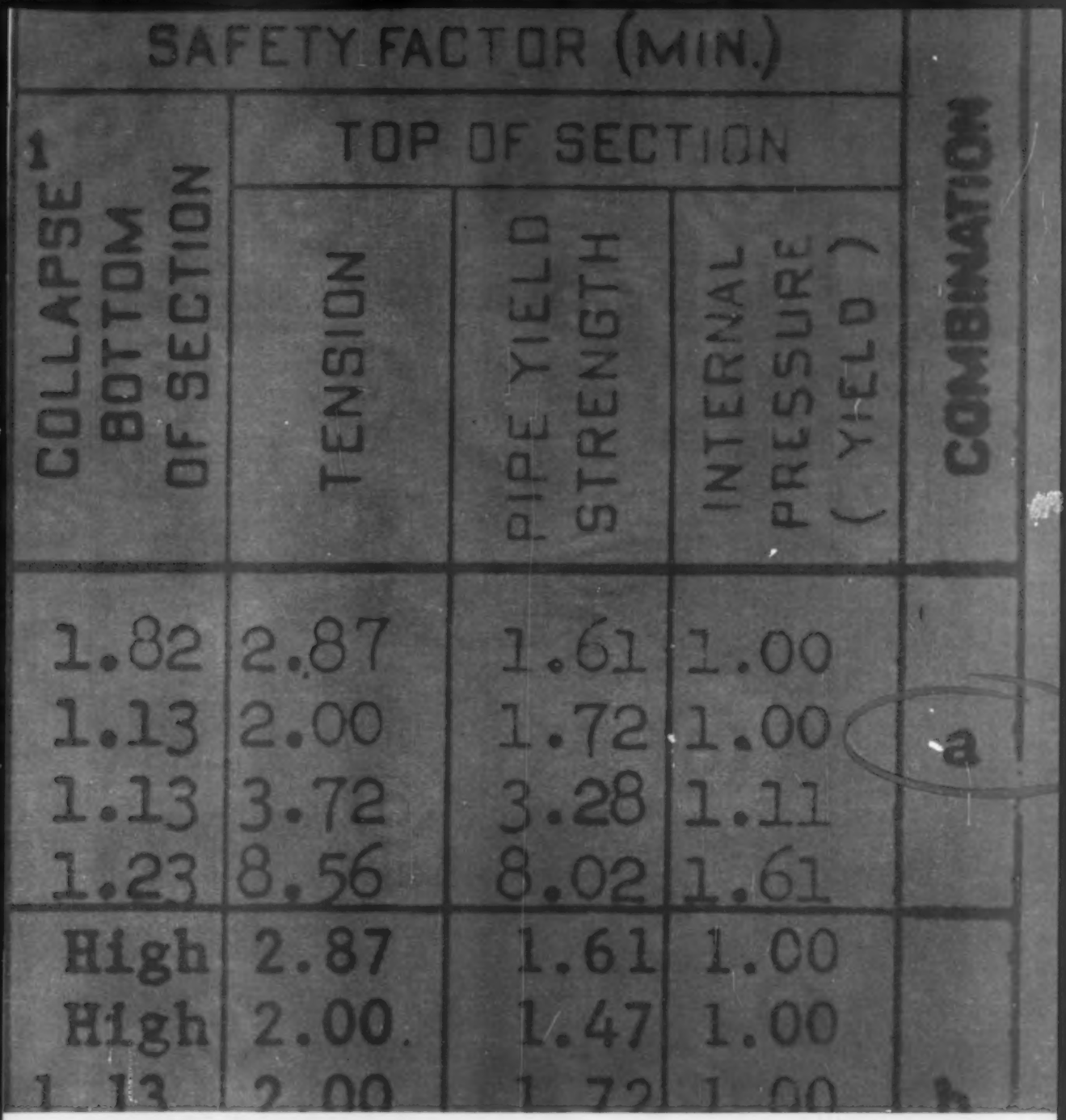

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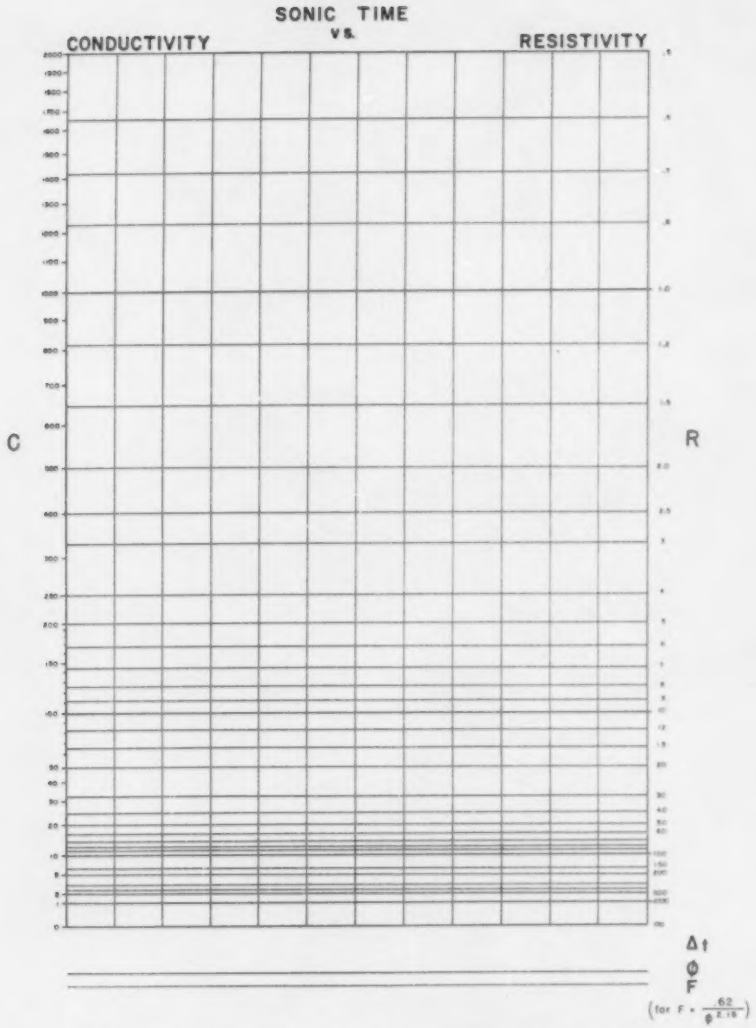

FIG. 6. Blank chart is used to plot Δ_t vs. R_{IL} or R_{LL}. Points located toward lower right are the most favorable, indicating higher porosity and lower water saturation.

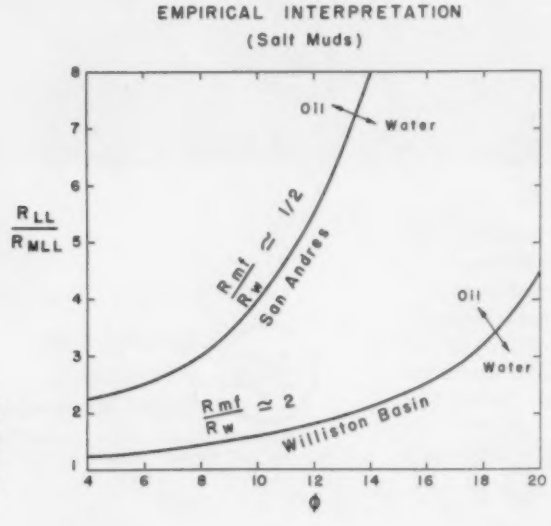

FIG. 7. Two curves are empirically derived for two fields. This type chart is helpful for choosing productive zones in development wells.

with depth is rare geologically, but examples are known. Again, the SP assists in giving the correct interpretation. When this condition is met, the shale base line of the SP shifts to the left (more negative) at the top of the bed. This base line shift reflects the connate water resistivity change. Base line shift (mv) $= -K \log R_{w_1}/R_{w_2}$, where R_{w_1} = water resistivity at the top of the zone. In the zone itself, the SP is essentially constant (no gradient).

Porosity, increasing with depth can also cause a gradient. Obviously, if porosity increases, the F becomes lower, so that R_o becomes progressively smaller. It is rare that nature gives regular changes of this kind, but still it does happen. Again, the SP will usually point to the correct analysis since it will remain constant if no oil is present. A good porosity log will show the cause of this type of gradient.

The steepness of the gradient can give clues. Fast gradients are due to the presence of high permeability. Thus, we would not expect fast gradients in low porosity areas; such gradients are usually due to porosity changes. However, this does not prove that the zone of higher porosity is water-bearing. It has to be interpreted on its own merits.

Invaded zone methods. One such method is the R_i comparison in sandstones. When R_t cannot be obtained due to thin beds or to deep invasion, use of the invaded zone values (usually from the 16 in. normal) may be helpful. Even the R_w does not have to be known but is assumed to be fairly constant. For such cases, the water saturation is about equal to the ratio of the invaded zone resistivities *providing the porosity remains constant:*

$S_w = R_i$ in water sand/R_i in oil sand.

If porosity is not constant and can be determined, the relation will read

$$S_w \simeq \frac{R_i \text{ in water sand}}{R_i \text{ in oil sand}} \times \frac{F \text{ in oil sand}}{F \text{ in water sand}}$$

Such relations work best in cases of moderate invasion.

The porosity index (or F_s) comparisons is also used. Sometimes, when the beds are very thin and/or R_w data unknown, use of a resistivity derived porosity index with a porosity derived from a sonic log or a neutron will locate pay zones qualitatively. The method is similar to the R_i comparison discussed above. The most successful application is by comparing a sonic F_S (obtained from *Fig. 1*) to F_R, which is a short investigation resistivity value divided by R_{mf}, such as R_{MLL}/R_{mf} or

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$R_{16\,in.}/R_{mf}$. When $F_R > F_s$, hydrocarbons should be present.

Location of gas pays, or gas/fluid contacts, is often easy by using the neutron with the sonic log. The neutron tends to give porosities which are too low and the sonic gives porosities which are too high in gas-bearing formations. Therefore, comparison of these logs should permit easy gas identification.

Conclusion

Several methods for semiquantitative interpretation have been suggested. In practice, only a few of these methods will apply to any one well. Checking by alternative methods is recommended if this is possible.

For best results, focused logging tools should be run. The need for reliable porosity tools has been pointed out many times. In fact, in difficult areas, such as in limestones and in all wildcats, two properly selected porosity logs can be very worthwhile. No one porosity device can be interpreted by itself without knowledge of lithology and/or extent of flushing.

Interpretation must be done with some imagination but always in keeping with basic fundamentals. Often, the most difficult job is to obtain reliable data to use. Once good values of R_w, porosity, and true resistivity are obtained, anyone can complete the work. The final step is knowing what to do with the S_w obtained. Predicting commercial production or water production accurately sometimes requires other information which is not usually available. Experience is needed to give final judgment on the meaning of the interpretation which has been performed.

Be optimistic! When studying a zone, think of it as oil-bearing until it is definitely proved otherwise. It is very costly to pass up a potential reservoir.

Nomenclature

d = Diameter of the hole
mv = SP deflection in millivolts
m = Cementation exponent
n = Saturation exponent
F = Formation resistivity factor
F_s = Formation resistivity factor derived from sonic log
F_R = Formation resistivity factor derived from invaded resistivity log
ϕ = Porosity
V_m = Velocity of the matrix in feet/second
Δt = Sonic transit time in microseconds per foot
R_t = Resistivity of the formation—uncontaminated zone
R_o = Resistivity of the formation when 100 percent water saturation
R_i = Resistivity of the invaded zone
R_{xo} = Resistivity of the flushed zone (close to bore hole)
$R_{16\,in.}$, R_{Lat}, R_{IL}, R_{LL}, R_{MLL} = Apparent resistivity of the 16 in. normal, lateral, induction, laterolog, microlaterolog, respectively
R_m = Resistivity of the mud at borehole temperature
R_{mf} = Resistivity of the mud filtrate at borehole temperature
R_w = Resistivity of the interstitial water
R_{wa} = Apparent resistivity of the interstitial water
R_z = Resistivity of the water mixture in the invaded zone
S_w = Water saturation, fraction of the pore space
S_i = As above, but in the invaded zone
S_{xo} = As above, but in the flushed zone

* * *

OPINIONS AND COMMENTS . . .

. . . voiced at the API's Southwestern District Meeting

DELEGATES to the Spring Meeting of the Southwestern District, Division of Production, American Petroleum Institute, held in Dallas, March 2-4, heard a wide variety of interesting comments. Here are some of the more noteworthy opinions:

Halbouty Charges Regulations Used As Political Expedients

Certain oil regulatory practices of the Texas Railroad Commission are political expedients which promote waste, disregard sound engineering principles, and may cause exploration capital to be diverted from Texas to other states.

These charges were made by Michel T. Halbouty, Houston independent operator, in a militant attack on Rule 37 of the Texas Railroad Commission. This rule permits drilling wells on small tracts and the subsequent assignment to these wells of a high allowable, which causes drainage from adjoining properties.

He warned that failure on the part of the commission to alter its approach to small-tract drilling might help to bring on federal control of oil production.

Mercer H. Parks Notes Decline in Inventiveness

Mercer H. Parks, Humble Oil & Refining Company, warned of a long-term decline in American inventiveness and called for greater understanding of the process of creative thinking as a means of avoiding further decline in the U. S. economic and military position.

"On the basis of relative population," he said, "the U. S. ranks seventh or eighth in scientific achievement as indicated by Nobel prizes, and this despite the fact that countries which are ahead of us have only one-quarter to one-third of one percent of their population in college.

Government Inquiries Hit by H. S. Skinner

Government, particularly the federal variety, came in for needling from Harold S. Skinner, director of public affairs for Continental Oil Company. Skinner referred to Congressional investigations as the greatest "all-purpose tool" which politicians have found.

"With the investigative apparatus in hand," Skinner said, "a Senator can either inform or mislead great masses of men and women."

Skinner's remarks were part of a plea for active participation by businessmen in politics to balance the growth of power by government and labor unions.

Jasper Outlines Selection Of Automatic Lease Control

Factors which influence the selection of various types of equipment for automatic control of lease production were reviewed by R. W. Jasper, Shell Oil Company, Midland, Texas.

He described most of the better-known methods and types of equipment, but cautioned that "the final decision can only be made by the company planning the installation."

Lease automation, he said, is simply a more advanced tool to be used in the industry's ceaseless effort to reduce costs and increase profits.

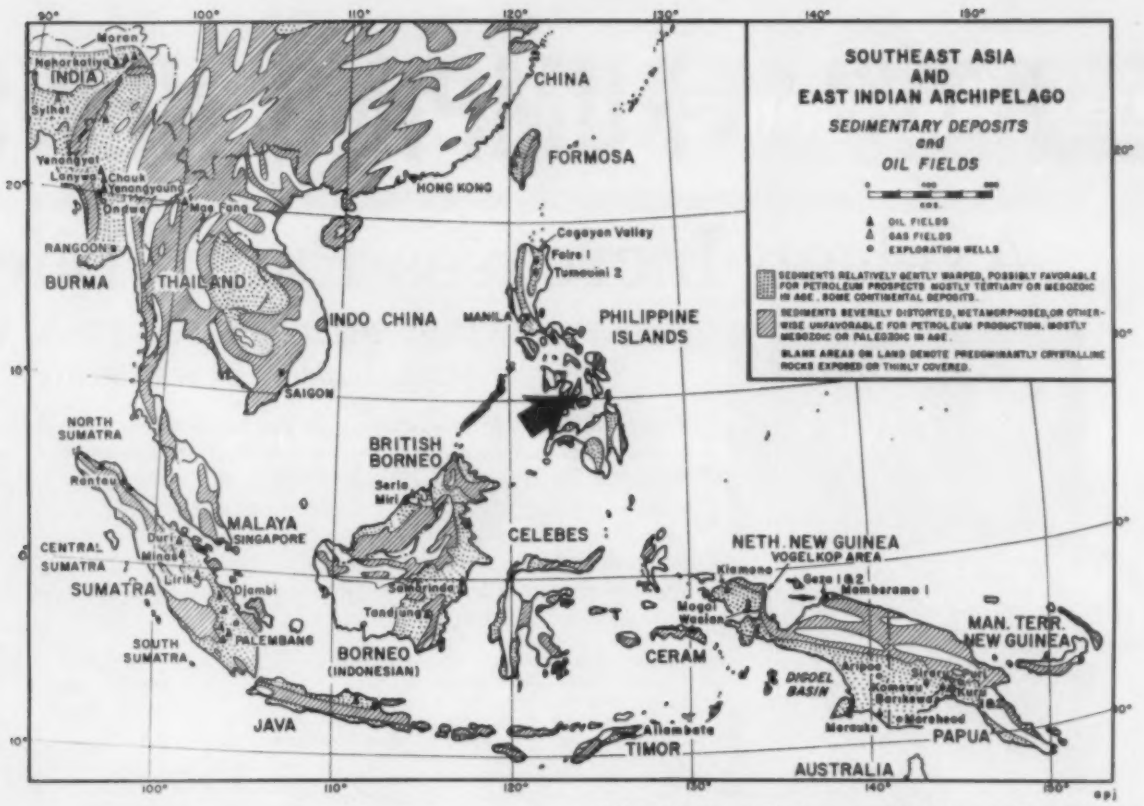

FIG. 1. Philippine Archipelago, one of the more promising exploration areas of the Far East, is shown above. Arrow points to recent shallow commercial oil discovery near Toledo on the Island of Cebu, locale of oil seepages known in 1888.

Cebu oil test promises . . .

First Commercial Oil Discovery For the Philippine Islands

Successful drillstem test near Toledo on West Coast of Cebu Island marks first possible commercial oil discovery after 63 years of sporadic exploration. Principal folds throughout region may be resurveyed for deep drilling

Joseph A. Kornfeld
Kornfeld International
Tulsa, Oklahoma

EXPLORATION FOR OIL in the vast Philippine Archipelago is due to receive a new impetus following the report of commercial showings of high-gravity oil at shallow depths from a test well on the west coast of the island of Cebu (see Fig. 1).

The apparent discovery well is situated near the old shallow Toledo oil field in the central portion of the island, near what might be called the Drake Well of the Philippines.

A Philippine-owned company, Republic Resources & Development Corporation reported that the first drillstem test was made during September from 1091-1107 ft. Gas to surface was estimated at 70,000 cu ft per day. Recovery in drill pipe was reported at 450 ft of 43 gravity pipeline oil.

A second drillstem test was made from 1257-1284 ft. Gas rose to surface after tool was opened and recovery in drill pipe was 750 ft of high-gravity oil and 50 ft of heavily oil and gas-cut mud.

The apparent discovery lies near eight shallow holes drilled to about 1000 ft, all of which bailed and tested 42-gravity oil.

The new discovery is situated near old core-holes drilled on a monocline of the Malubog formation of Tertiary upper W Miocene-Pliocene age. The discovery is an enigma, since the prominent Daanbantayan structure in northern Cebu failed to produce after four deep tests; and there is no major folding associated with the current discovery. However, the shallow pay depths and the high gravity of the oil with the possibility of developing a shallow reserve is of immediate interest.

A more significant implication of the strike is a re-examination of major structural features throughout the principal islands of the Philippine Archipelago. Also, a new examination is being made of the buried structures which

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Hardened Barrel Tube is flame-hardened to a uniform minimum depth of .025". Finish on all tubes and plungers is controlled to provide maximum lubricating qualities, retains oil.

Finest Automatic barrel tube honing equipment in industry has a built-in micrometer which makes a pass through the tube with each stroke of the hone. Automatically stops machine when desired I.D. tolerance is achieved.

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Contact your Axelson man about new slim hole developments. Typical is Axelson's Thru-Hard coupling for slim hole production. It's used in place of a hardened and ground coupling. The Thru-Hard coupling has a built-in toughness without sacrifice of strength. Try it and see.

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Longer Pump Runs Result From Barrel Tube And Plunger Manufacturing Developments

Equipment life and production runs can be increased through better barrel tubes and plungers in proper combination. Axelson field representatives are trained to prevent customers from paying for a premium tube or plunger when it may be unnecessary, because, in many cases, a more economical combination may be available. In addition, Axelson has spent thousands of dollars improving manufacturing techniques to produce the most complete selection of barrel tubes and plungers available. Here are the facts:

Barrel Tubes—Axelson's hardened tube has the heaviest case known for maximum wear resistance. It is combined with a strong, resilient, tough outside diameter. Only the I.D. is case-hardened. Threaded ends are unhardened to retain their inherent toughness.

A uniform case depth and hardness is maintained, eliminating soft spots. Axelson helped steel companies develop non-destructive ferro testing to avoid split tubes. Quality is upheld through concentricity, straightness, finish and closely maintained tolerances.

Unhardened tubes are produced for mildly corrosive wells, etc. Exceptionally hard chrome I.D. tubes are available for salt water type corrosion conditions, particularly where abrasion is a problem.

Plungers—The best runs are accomplished by a proper combination of tube and plunger. A careful choice of both is necessary. Axite, chromium plated, hardened steel, regular steel, niaxite, and composite (eutectic, regular iron, hard cast iron) plungers are produced by Axelson to give production men as wide a selection of equipment as possible.

For example, Axelson's Axite plunger surfaces are highly resistant to abrasion, impervious to salt water, extremely resistant to hydrogen sulphide, and non-galling (lowest coefficient of friction of any type plunger available). Axite particles have a hardness of 9 on the Moha Scale. They are best for extremely corrosive conditions.

Field Tested—A highly abrasive and corrosive California well in the Bakersfield oil field had consistently chewed up ordinary plungers (such as one shown at right) in a matter of several weeks. Axite plungers were finally installed. The Axite plunger shown at left ran 25% longer than the best previous plunger.

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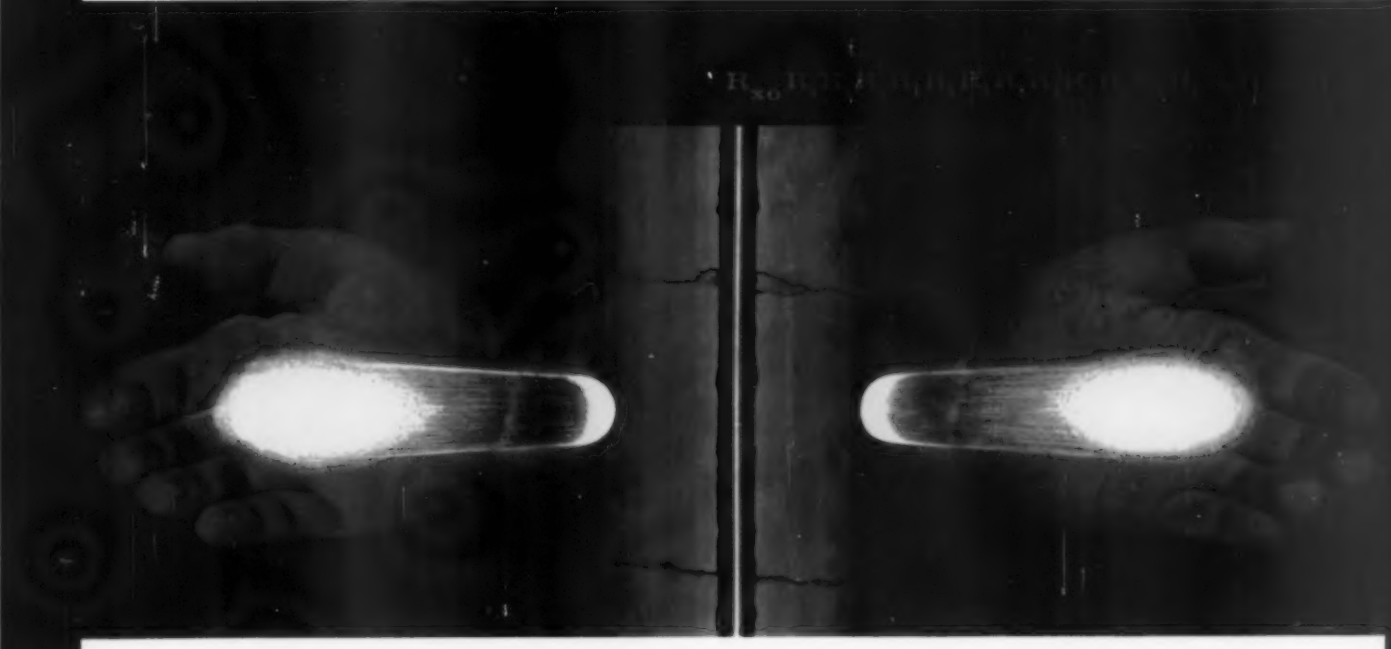
The New Schlumberger Deep Induction Log

reaches twice as deep to give twice the contrast between water and oil



Engineered to overcome deep invasion, the new Schlumberger Deep Induction Log retains all the advantages of the Induction-Electrical Log . . . symmetrical response, thin bed definition, detail for correlation, simultaneous recording with 16″ SN and SP . . . *plus* an investigation twice as deep which gives twice the contrast between water and oil.

Your Schlumberger engineer will be glad to explain this new service in detail. It's another product of Schlumberger research and engineering to meet the challenge for greater efficiency in oil finding.

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ORBIT VALVES®

WHERE CONTINUOUS HEAVY DUTY SERVICE IS ESSENTIAL.....

ORBIT FORGED STEEL PRODUCTION VALVES

Orbit Forged Steel Production Valves in Service on Manifold for Gas Unit Near Freer, Texas. Gas from 20 wells is being fed into Hydrocarbon Recovery Unit.

Orbit Valves shown here are installed on continuous heavy duty service. Orbit Forged Steel Production Valves are so designed that seats contact only at closure. Dust and abrasives carried by gas from wells cannot get between seats because valve is self-cleaning and dust carryover is swept through valve by gas stream. There are no voids or cavities in the Orbit Valve for gases or fluids to become trapped in — when the valve is either in an open or closed position.

ORBIT VALVE COMPANY

P. O. BOX 699 TULSA, OKLAHOMA, U.S.A.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

are believed to exist beneath major unconformities in the Tertiary beds, and may not coincide with known surface expressions of these features.

The presence of oil and gas seeps in various parts of the archipelago — a vast region of the Far East extending for more than 600 miles from north to south and as much as 400 miles from east to west near major markets for petroleum products — encourages explorationists to take a resurvey of production potentials. This area is undergoing rapid industrialization.

Exploration History

Oil seeps have been known for many years on Cebu. Oil was first noted by the Spaniards in 1888. In the year 1890, Enrique Abella y Casariego, in his report entitled "Descripción de la Isla de Panay," described shales which yielded small quantities of petroleum. G. F. Becker, geologist with the United States Geological Survey, in his 21st annual report published in 1901 noted that petroleum was found at Asturias, Toledo, and Alegria.

The first recorded drilling operations in the Philippines were conducted during 1896 near Toledo, Cebu. Two wells were drilled on the Smith, Bell & Company estate 164 ft apart near the old oil seeps. One of the wells bailed considerable oil after drilling to a depth of 800 ft and the other well produced a small amount of oil after drilling to 1122 ft. However, development was abandoned in 1897 due to a political uprising.

No additional drilling was conducted on the island until 1936, when the Philippine mining boom revived interest in the area. Several shallow test wells were drilled in the Toledo area to depths of about 500 ft and small amounts of oil were bailed from some of the wells.

Two years later, deep drilling was commenced on the Barili anticline on the south-central portion of the island, but the well was abandoned as dry at a depth of 6000 ft.

The next significant deep exploratory test was drilled to a depth of 8326 ft in the fall of 1940 at Daanbantayan in the northern portion of the island of Cebu. With the invasion by the Japanese in the early part of 1942, drilling was halted and the equipment lost to demolition forces of the invaders.

Following World War II, another deep test was drilled 100 ft S 30 deg E from the discovery well, and it encountered basement rocks at 9934 ft. High-pressure gas of low volume was found and some oil showings were encountered at several zones in the Tertiary rocks, but detailed production tests failed to develop commercial production.

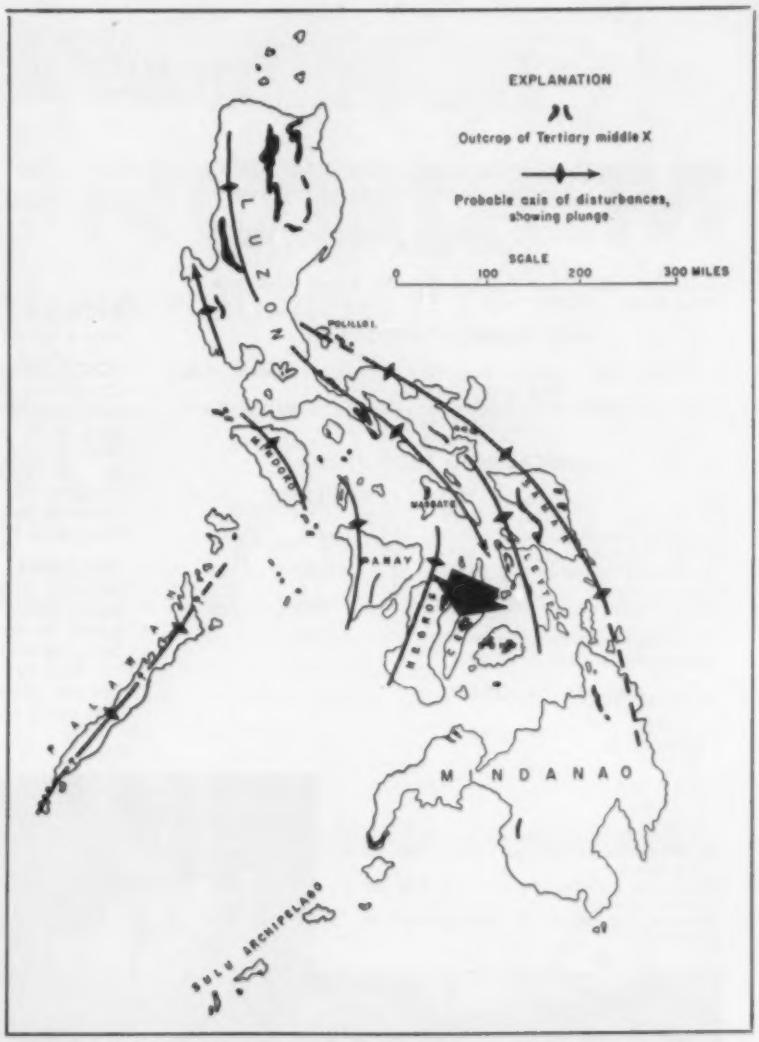


FIG. 2. Principal structural axes of major geologic structures of the Philippine Archipelago, extending over a vast area in the Far East, are being re-examined in the current search for oil and gas reservoirs after recent discovery of shallow oil on the west coast of Cebu. Arrow points to apparent discovery well.

Seismic surveys conducted in 1948 led to staking of Daanbantayan No. 3 three miles N 60 deg E from the first two tests. In drilling to a total depth of 7469 ft in the basement rocks, two gas zones were found in the Tertiary Barili limestone at 2064-2074 ft and in the Tertiary Maingit formation at 3830 ft. The well was completed flowing 80,000 cu ft per day before it was shut in.

A fourth test was drilled on the crest of the subsurface structure which was determined by reflection seismograph survey. It was located one mile southwest of the village of Bagay. In drilling to a total depth of 5909 ft in basement rocks, two gas zones were encountered in the Barili limestone at 1874 ft and 2024 ft, but production tests failed to isolate the free gas from salt water and the well was plugged.

Topography

Cebu is one of the Visayan group of islands in the Philippine Archipelago. It lies between the islands of Negros to the west and Bohol and Leyte to the east. Cebu is a long, narrow island, and its major axis trends slightly east of north turning due north at the northernmost extremity of the island.

A topographic divide trending north-south along the center of the island is the principal physiographic feature. The coast of Cebu reflects a series of alternating valleys and ridges extending in an east-west direction.

Structural Geology

Corby[1] states that the principal struc-

You save drilling dollars with

THE

MUD PROBLEM: Overcome pressure differential sticking (wall sticking) of drill pipe and casing.

WELL DATA

Location: Lake Boeuf Field, Lafourche Parish, Louisiana
Total Depth: 13,685′

MUD ADDITIVE PROGRAM

0′ to 8,000′ Native mud plus AQUAGEL*, caustic soda and Q-BROXIN**
8000′ to 13,685′ Gyp—Q-BROXIN emulsion. TRIMULSO* and DMS† below 7″ liner depth

TYPICAL MUD PROPERTIES

Depth	12,000	12,800	13,315[1]	13,653[2]
Weight, ppg	15.8	16.1	16.1	18.1
Viscosity, sec. API	60	55	60	65
Plastic Viscosity, cp	50	48	52	71
Yield Point lb/100 sq ft	15	7	12	14
Filtrate, cc API	21.8	2.0	2.2	0.5
Calcium, ppm	840	1360	1600	720

[1]Before addition of TRIMULSO and DMS
[2]After addition of TRIMULSO and DMS

CASING PROGRAM

Size Inches O.D.	*Depth Set Feet*
13⅜	3,022
9⅝	10,997
7 (liner)	13,301
5 (liner)	13,685

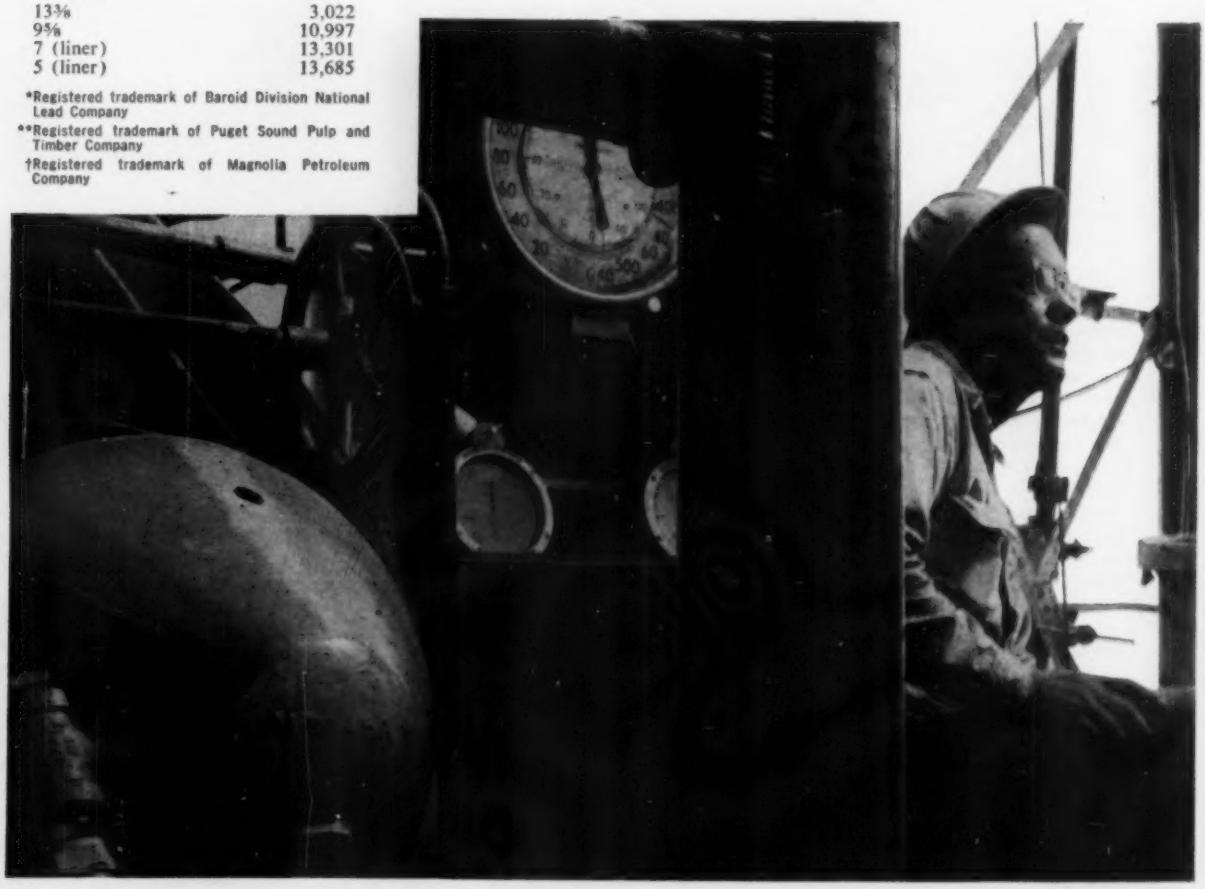
*Registered trademark of Baroid Division National Lead Company
**Registered trademark of Puget Sound Pulp and Timber Company
†Registered trademark of Magnolia Petroleum Company

PROBLEM: To prevent differential sticking of drill pipe. Insure landing and cementing of liner at total depth.

DISCUSSION: High mud weights are required to contain abnormally high formation pressures in this field. The difference between the mud column pressure and the pressure in the porous zones may cause differential sticking of drill pipe and liners. Differential sticking is evidenced by: the tendency for drill pipe to stick while making connections, running directional surveys, etc.; full circulation of the mud is possible while the pipe is stuck; and there may be no previous history of tight hole.

SOLUTION: Pilot tests on mud samples and previous experience with comparable jobs indicated that TRIMULSO would alleviate this troublesome condition. TRIMULSO was added to this emulsion mud while the mud weight was being increased to 18 ppg.

This well was successfully drilled to its objective without any difficulty with stuck drill pipe, and the 5″ liner was easily run and cemented.



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a Baroid Mud Program

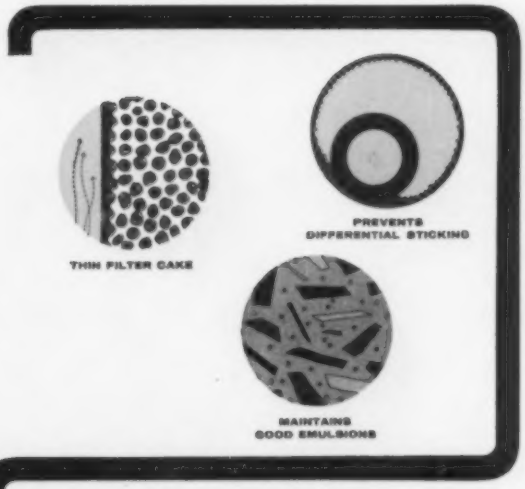
MUD PROBLEM

... and its solution

This case history shows again how a complete Baroid mud program helps accomplish your drilling objective. A costly fishing operation was prevented by the use of the specific product TRIMULSO.

Baroid's previous experience enabled the diagnosis of the potentially costly fishing job that would result from differential sticking. Previous experience also resulted in prevention of the trouble by the engineered use of TRIMULSO.

This is more proof that Baroid's new concept of modern marketing brings you added advantages. You get an *integrated service* that combines engineering skills developed in all drilling areas, quality-controlled products and complete delivery service that *saves your drilling dollars!*



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Armour bactericides offer low cost corrosion protection!

Bacterial analysis of untreated water supply, by Armour technical service man, indicates the presence of 27,000 or more sulfate-reducing bacteria per ml. of water. Black coloration of broth medium indicates growth of sulfate-reducing bacteria.

ARMOUR INDUSTRIAL CHEMICAL

Armour's Duomeen* compounds are serving a dual purpose for oil field operators throughout the country. These Armour chemicals not only control bacteria effectively, but reduce corrosion as much as 95% . . . at costs as low as one mil per barrel of treated water.

Using these Armour chemicals, operators realize savings by reducing costly remedial measures such as acidizing, tubing replacements, etc. Further savings are also realized by less down time and lower power costs resulting from lower injection pressures.

Relying on established and industry-approved tests Armour strives to help operators improve and maintain peak production efficiency. These field tests aid Armour's technical service men in making time and money saving recommendations. In the case shown here, Duomeen CD-50 is used for control of sulfate-reducing bacteria in water floods. The small inset pictures illustrate the effectiveness of this Armour chemical.

For complete detailed information on Armour's bactericide-corrosion inhibitors and other chemicals for oil production, write for the booklet, "Armour Organics for Increased Oil Production." Samples of Duomeen CD-50 and other oil production chemicals for your own testing are also available.

Using Armour recommended treatment of Duomeen CD-50, colorless broth medium shown in inset indicates complete control of sulfate-reducing bacteria after 30 days incubation.

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tural axes of Cebu Island exhibit a trend of N 20 deg E in the southern part, N 45 deg E in the central part, and N 10 deg W to due north in the north end of the island in both the pre-Barili and post-Barili structures. (The Barili formation is of Tertiary upper X age.) Pre-Barili structures were rejuvenated by the post-Barili deformation.

In the vicinity of the new apparent oil discovery near Toledo, there are no major structural features. However, post-Barili deformation, has contorted the sediments into a structural complex of numerous minor, local folds.

The principal structures in pre-Barili time on the island of Cebu are:

(1) A high area of basement rocks paralleling the present eastern coastline from Oslob to Danao;

(2) A prominent synclinal area paralleling this high on the west;

(3) A syncline, the axis of which parallels the west coast and possibly joins the main synclinal axis between Pinamungahan and Barili; and

(4) Another high area of basement rocks separating these two synclines and occupying the center of the island from Cebu to Sogod. Two smaller anticlines exist between the principal synclinal axis and Alegria and Malabuyoc.

Daanbantayan anticline is a long, gentle north-trending fold exposing Barili marl surrounded by Carcar limestone. South of Bogo are found the northward-trending Bogo and Tangob anticlines, the first in Barili marl, and the second in Barili limestone.

Irving[2] states that Cebu is an elongated anticlinal island 140 miles long and 25 miles wide at its broadest part. Basement rocks are exposed in the core of the island in its north-central part which coincide with the prominent topographic divide.

Joseph A. Kornfeld, *manager of Kornfeld International, Tulsa, Oklahoma, heads a firm of consulting petroleum tcehnologists engaged in conducting exploration work on foreign oil and gas concessions. Associated with the firm are photogeological, geophysical, surface and subsurface geological personnel. Principal offices are in the Mid-Continent Building in Tulsa, Oklahoma.*

Since 1957, the firm has conducted exploration work on concessions in France, Morocco, Nigeria, Algeria, East Pakistan, West Pakistan, India and Mexico.

Kornfeld was formerly exploration editor for Petroleo Interamericano covering Central and Latin America during 1950 to 1954 and served on the editorial staff of the Oil and Gas Journal during that period. Prior to 1950 he was reservoir engineer for Sohio Petroleum Company and The Texas Company. He is listed in the current Sixth Edition of "Who's Who in the Southwest."

He is a special lecturer on natural gas economics at the School of Gas Technology sponsored by the Petroleum Extension Division of the University of Texas, and is author of a text on natural gas.

Kornfeld has lectured at Algiers and Mexico City before the International Geological Congress and in Paris and Munich meetings of the International Congress of Pure and Applied Chemistry.

The older Tertiary formations exposed around the basement core are folded along northeast-trending axes, and Tertiary upper X and younger strata have been arched into a broad elongate dome that dips off the flanks and plunges beneath the sea at both ends.

The sandstones of the Malubog and Maingit formations appear to be capable of providing favorable porous zones for reservoir rocks. The Alegria and Barili anticlines of Southern Cebu; and Daanbantayan and Bago anticlines at the northern end of the island appear to possess favorable stratigraphic relations and potential structural traps for petroleum accumulation.

TABLE 1. Stratigraphic Sequence — Island of Cebu.
(Ref. Irving, Earl M. "Geological History and Petroleum Possibilities of the Philippines," Bull. AAPG Vol. 36, No. 3 March, 1952.)

Formation	*Age*	*Thickness (ft)*
Carcar reef limestone	Z	500– 1,300
Barili marl	X_a to Y	660– 1,650
Barili limestone	X_a	650– 1,150
Maingit	X_m	
Sandstone		1,800
Conglomerate		1,875
Limestone		150
Toledo limestone	X_1 to X_m	650– 800
Mount Uling limestone	X_1	650– 800
Malubog formation	W_a	1,650– 3,900
Alpaco member		
Upper coal measures		
Upper Binabac limestone		
Lower coal measures		
Lower Binabac limestone		
Cantabaco member		
Cebu formation	W_a	
Cebu orbitoid limestone		250– 330
Cebu coal measures		160– 410
Total		8,995–14,165

Petroleum Market

The Philippines afford the sixth largest market for petroleum products in the Far East ranking behind Japan, Australia, India, Indonesia, and Malaya.

Consumption during 1957 was 45,000 bbl per day and for 1958 was estimated at 50,000 bbl per day. Domestic requirements of petroleum products are rising at the reported rate of 11 percent per year.

TABLE 2. Typical Gas Composition.
Daanbantayan Anticline,
National Petroleum Development Company,
Well No. 3
Island of Cebu, Philippine Archipelago

	Molecular Percentage	*Liquefied Fractions (Gal per 1000 cu ft)*
Methane	97.53	
Ethane	1.06	
Propane	.15	0.04111
Isobutane	.06	0.01974
N. Butane	.98	0.31104
Isopentane	.16	0.0585
N. Pentane	.04	0.0133
N. Hexane	.02	0.0089
	100.00	0.45256

There is only one refinery in the Philippines with a crude capacity of 13,000 bbl and a catalytic cracking capacity of 5400 bbl per day.

References

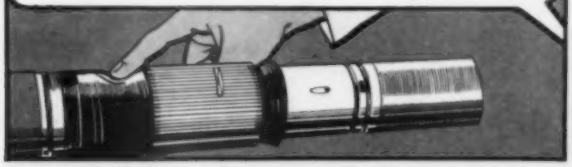
1. Corby, Grant W. et al, "Geology and Oil Possibilities of the Philippines," Republic of the Philippines, Dept. Agri. and Nat. Res., Tech. Bull. 21, (1951).
2. Irving, Earl M. "Geological History and Petroleum Possibilities of the Philippines, Bull. AAPG Vol. 36, No. 3, (March, 1952) pp. 437-476.

★ ★ ★

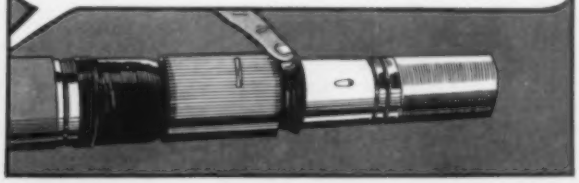
HERE'S A REPORT ON THE DURABILITY OF THE RUBBER-TYPE ELEMENTS USED IN OUR TYPE OF GAS LIFT VALVES — AND HOW THE DESIGN PRINCIPLE SAVED A SOUTH TEXAS WELL OWNER THE COST OF A CONVERSION WORKOVER.

The valves covered by this report have been in the well for 5 years now—and have given perfect service. What's more, they saved the operator the cost of a workover just three months following installation, when the well had to be converted from continuous to intermittent lift. The well has been produced intermittently since that time and the well owner is pleased with the operation of the valves.

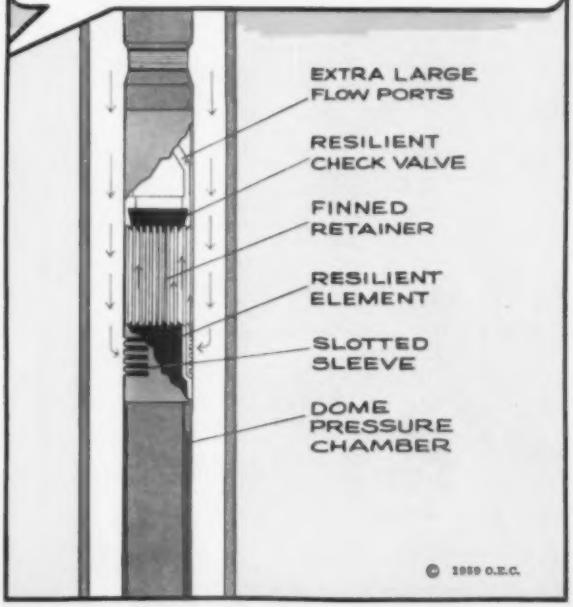
Here, let me show you the many advantages of the resilient elements in our valves. First, because this main element is resilient, it resists erosion from the system gas. Second, the flow area across the element is the largest flow area of the valve, which not only helps to reduce any cutting action from the system gas but minimizes the movement required to admit gas from the annulus during operation. These features are designed to prevent fatigue.



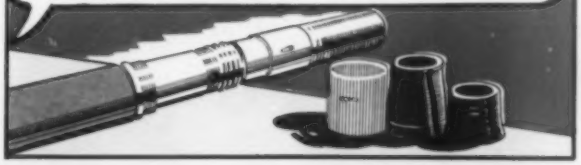
The same principles apply to the check valve here. It compresses just slightly as gas passes over it, then —when necessary to check back pressure from the tubing—it acts to form a bubble-tight seal against the finned retainer and inside wall of the valve. And the rubber-to-metal seal principle of both resilient elements eliminates the excessive wear normally associated with metal-to-metal, stem-and-seat type valves.



I'll show you how we bond the main valve element to the valve mandrel assembly in a minute—but first let me show you this flow diagram of our Type C Gas Lift Valve. Pressure from the valve dome holds the main valve element closed across the slotted ports. When gas pressure in the annulus exceeds the set pressure of the valve, the main valve element opens. When the pressure from the annulus drops below the set pressure of the valve, the valve closes.



Now here's how we bond the main valve element to the valve mandrel assembly. First we serrate the sealing surfaces of the mandrel assembly to give it a superior bonding surface. Then we apply a special bonding cement, slip the rubber element into place, and bake the complete assembly for one hour at 375° F. This produces a pressure-tight seal at the element end of the dome chamber. As a result, our valves can be expected to maintain their set pressure indefinitely.



If you're planning a new gas lift installation and want to RUN VALVES THAT WILL STAY IN THE HOLE and give you trouble-free service — INSTALL OTIS GAS LIFT VALVES. They have no moving metal parts . . . no bellows to fatigue . . . no metal seats to cut out . . . and they're designed to operate continuously or intermittently without having to be pulled for conversion. Contact one of our gas lift specialists at the Otis office nearest you. He'll be glad to show you these and other exclusive features and explain how Otis Gas Lift Valves are designed to save you money.

Otis - "First in Gas Lift Control"

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General Offices: 6812 Denton Drive Dallas

Branches Throughout the Oil Country

SUPPLIERS' PARADE

Halliburton Oil Well Cementing Company. A special products division for marketing processes, instruments and other developments in areas outside its usual fields of activity has been formed by Halliburton Oil Well Cementing Company. Tom E. Morton heads the new division.

T. E. Morton

Jack Stewig

Waukesha Motor Company. Jack Stewig has been named product manager of the CFR division of Waukesha Motor Company, manufacturers of laboratory type engines.

McCullough Tool Company. M. W. "Tiny" Chambless has been appointed area sales and service manager of the southwest Texas area of McCullough Tool Company's Eastern division, to succeed the late Tom Parsons. A. L. "Al" Simpson has been named sales representative in the newly created North Area of the Pacific division.

Five outstanding petroleum engineering students at the University of Alberta, Edmonton, were recent recipients of the company's annual scholarship awards. These students, in the third and fourth years of petroleum engineering, are John Raines, Allen Hoschstein, William Longson, Harry Ripley, and John Thairn.

M. W. Chambless

John Grant

Byron Jackson Tools, Inc. John Grant has been appointed plant manager of the PB products section of Byron Jackson Tools, Inc. L. E. Fuller succeeds Grant as chief engineer.

United States Steel Corporation. Louis W. Mason has been appointed general manager of sales of United States Steel's National Tube Division. He succeeds Robert E. Williams, who became vice president of sales for National Tube.

U. S. Steel's Oil Well Supply Division has announced the appointment of Gerritt I. Wyckoff as manager, waterflood and well servicing pump sales. His new duties will be division-wide, with headquarters remaining in Tulsa, Oklahoma.

G. F. Goetzinger, vice president-treasurer of the Oil Well Supply Division, retired recently after 45 years of service.

William S. Lennard has been appointed manager, drilling equipment sales, of the division in Los Angeles. B. J. Travis has been promoted to district engineer at Midland, Texas.

Baash-Ross. S. D. Goins has joined the Baash-Ross division of Joy Manufacturing Company as operation manager in the company's Odessa plant.

Western Geophysical Company. Dean Walling, president, has been chosen "alumnus of the year" from among 20,000 former students of Abilene Christian College, Abilene, Texas.

The Happy Company has announced changes in their sales staff and the opening of a new sales office in Dallas. Roy L. Rowe, former district manager of the North Oklahoma sales area will head the Dallas office. Jack C. Hisaw has been named as district manager of the North Oklahoma area.

Petroleum Equipment Suppliers Association. H. R. Safford, Jr. has been elected executive vice president of PESA. Safford, who maintains headquarters in Houston, has been executive secretary of PESA since 1946.

Drilco Oil Tools, Inc. Dick Norton has been transferred to Lafayette, Louisiana to be in charge of the Louisiana sales district. Paul Myers has been appointed to handle sales in the Oklahoma area.

Longhorn Supply Company was appointed first distributor of the new W-K-M pressure sealing gate valve. W-K-M plans to market the new valve exclusively through oilfield supply stores and distributors.

Willis Oil Tool Company recently moved into their newly constructed plant and office facilities. Formerly located at 3440 Pine Avenue, Long Beach, California, the new facility is located at 2451 Palm Drive in Long Beach on the north slope of Signal Hill.

Mission Manufacturing Company. James A. Groves has joined the company as sales representative for the Edmonton, Alberta, area.

Merla Tool Corporation. Paul Lamb has been appointed sales engineer for the Dallas-based oil tool and equipment manufacturer.

National Supply Company. Owen P. Lake has retired after 36 years service with the National Supply Company. He was manager of a branch office at Torrance, California.

Skinner Brothers Company. W. E. (Bill) Esslinger, recently named sales manager for Skinner Brothers Company, heads a staff of field representatives located in all major oil producing areas in the U. S.

W. E. Esslinger

J. R. Yancey

Oil Center Tool Company. The promotion of J. R. (Dick) Yancey to vice president of the Oil Center Tool Company has been announced. Yancey will also continue in his current role of chief engineer.

Schlumberger Well Surveying Corporation. Four changes in field personnel have been announced by Schlumberger Well Surveying Corporation. R. H. Neustaedter has been named location manager for Gainesville, Texas, and B. F. Irvin has the position of sales engineer at Shawnee, Oklahoma. D. E. Roth, who was field engineer general at Lubbock, Texas, was named sales engineer for that location. T. E. Lovan, field engineer general at Evansville, Indiana, was moved to the Northeast division as sales engineer.

Cummins Engine Company, Inc. J. B. (Ben) West has been appointed manager, western hemisphere oilfield sales for Cummins Diesel International Ltd., representing the company in Latin America and Mexico.

Liberty Manufacturing Company of Texas. The appointment of P. B. Martin to represent Liberty Manufacturing Company of Texas in the Oklahoma-Kansas district has been announced.

Milwhite Mud Sales Company. New duties as area sales manager for Milwhite Mud Sales Company have been assumed by W. T. (Dub) Kelly. He will continue

W. T. Kelly

Bill Martin

to work out of the company's general office in Houston, Texas. Bill Martin was made assistant zone manager in charge of warehouse operations, New Orleans.

Plastic Applicators, Inc. Sales engineers and executives of Plastic Applicators, Inc., attending the company's recent winter conference in Houston, Texas, heard details of a 1960 development program involving research, inspection facilities, and marketing methods. It was announced that Bruce Gifford, formerly with Rubber Applicators, a subsidiary, now heads an enlarged research and development department. Indications were that advanced coatings, supplementing the present line, would be available soon. Having completed a $400,000 expansion and automation program, doubling plant capacity, the company announced additional expansion of facilities totaling $200,000.

George J. Fix Company held an exposition of new products for industrial power transmission January 13-17. The show was held in the company's new offices and warehouse, 1901 South Good-Latimer Expressway, Dallas.

Eleven major manufacturers in the field of power transmission exhibited their newest products. They included Boston Gear Works, the Chain Belt Co., Shafer Bearing, Koppers Co., Inc., Heli-Coil Corp., Aerol Co., Faultless Caster Corp., Reeves Pulley Co., Reliance Electric, Warner Electric Brake and Clutch, and U. S. Rubber Company.

per-form'-ance operation or functioning, usually with regard to effectiveness.

WEBSTER

A new concept in hydraulic pumping—The Balanced Design—gives the Oilmaster Subsurface Hydraulic Production Unit a level of performance that challenges many of the concepts of artificial lift. If performance is measured in terms of pump capacity, the rated output of an Oilmaster hydraulic in 2" tubing exceeds the potential of all but the highest productivity wells. In wells where capacity is not a production criterion, the same unit can operate as slowly as one-tenth its rated capacity with complete stability and with unprecedented efficiency and dependability. Ask your Oilmaster representative to give you the details on the effectiveness of this high performance method of production, or write for Bulletin E5903.

Pumping is our Business

In 1924 the Fluid Packed Pump Company introduced a totally new concept in rod pumping — a unique pump without conventional barrel and plunger, but employing three telescoping tubes to utilize the produced fluid as its packing medium.

Since 1924 this Fluid Packed Pump — now more commonly known as the Oilmaster Multiple Tube Pump — has become the acknowledged leader in producing sandy or abrasive wells in pumping fields the world over. Its design has frequently been copied, but never equalled.

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DIVISION OF THE NATIONAL SUPPLY COMPANY
Los Nietos, California
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National Supply Company, Pittsburgh, Pa.
Export: The National Supply Co.
Export Division, 600 Fifth Avenue, New York
Co-Distributors: Union Supply Co.
Beacon Supply Co., Industrial Supply Co.

The National Supply Company. After 40 years of service with The National Supply Company, E. M. Gretzler has retired. Beginning as a field salesman in 1919, he served in various capacities in this country and abroad, and since 1956

E. M. Gretzler

J. L. Holmquist

has been vice president of The National Supply Company of Mexico, S. A.

John L. Holmquist has been made director of research, tubular products, for the company, with headquarters at the Pittsburgh general offices. At the same time, Thomas L. Blose was appointed director of product engineering at Ambridge, succeeding Holmquist, and Lawrence W. Peugeot was appointed assistant chief engineer, succeeding Blose.

Garrett Oil Tools, division of U. S. Industries, Inc., has announced a series of organization changes.

D. E. Whittenberg, vice president, sales, is assuming broader responsibilities and in the future will be responsible for executive office customer relations and will assist the president with the general administration of the division. He will also serve as general manager of the division in the absence of the president.

He will maintain his office in the division's headquarters in Longview, Texas.

Robert E. Dunn has been named manager of marketing, where he will be responsible for supervising and directing the sales department.

J. T. Conner, who has served as South Louisiana district manager for several years, has been promoted to the new position of field sales manager. He will supervise all sales districts, including Garrett Oil Tools, Ltd. (Canada) and domestic sales agents. Conner will move to the company's Longview headquarters.

Another new position, manager of sales training, will be filled by R. V. McAfee. McAfee will be responsible for establishing and conducting all sales training programs. He has been associated with Garrett since 1950 and will continue to be headquartered in the firm's Houston office. C. G. Phillips, sales engineer in the South Louisiana district will temporarily supervise that district.

Kendavis Industries, Inc. Key promotions have been made in Kendavis Industries, Inc. Named were Murl C. Cornish

M. C. Cornish

G. E. Larkin

as vice president and comptroller, and Goldie E. Larkin as director of automatic accounting division.

Dresser Industries, Inc. Keith R. Beeman, president of Southwestern Industrial Electronics Company, a division of Dresser Industries, Inc., has accepted a position with the parent company. He will remain in Houston and will be engaged primarily in the investigation of new product possibilities and the broadened application of present products. George A. Peck has been appointed to succeed Beeman as president of Southwestern Industrial Electronics. Peck was formerly vice president and general manager of the Electronics division of Stromberg-Carlson Company. John Joss, formerly with the advertising and publications department, was appointed administrative assistant to Leigh Taylor, SIE's vice president of marketing.

Southwestern Industrial Electronics recently sold their newly-developed PMR-20 portable FM Seismic recording system to each of the following companies: Asiatic Petroleum, New York City; Geophysical Associates International, Houston; and Gewerkschaft Brigitta, Hanover, Germany.

As a part of its expansion program, Lane-Wells Company, another division of Dresser Industries, Inc., has opened a new technical oilfield service location in Liberal, Kansas. J. B. Russell is field service operating engineer in charge.

Ralph Hughes was named vice president-manufacturing for Security Engineering Division, having previously been manager of manufacturing for the company's plants in Dallas, Texas and Whittier, California. William B. Thomas was appointed regional special sales representative for the Dallas-Fort Worth area with offices at the firm's Dallas headquarters. Security produces rock bits for drilling oil and gas wells.

Ralph Hughes

E. F. Snow

Joy Manufacturing Company. Earl F. Snow has been named materials manager of the Baash-Ross Division of Joy Manufacturing Company and is located at the home office in Houston, Texas.

W-K-M, Division of ACF Industries, Inc. The complete line of W-K-M valves will be manufactured, sold, and serviced by Huber and Mayer of Vienna, Austria. W-K-M has other foreign licensees in Austria, France, Great Britain, and Mexico, and sales offices in Germany, Italy, South and Central America.

Lufkin Foundry and Machine Company. The 1960 annual sales meeting of Lufkin Foundry and Machine Co., oil field division, brought more than 50 men from the United States, Canada, and South America to Lufkin, Texas for a conference. Home office personnel participating brought the total to more than 100. L. A. (Pete) Little, vice president, and Cooper Richards, assistant sales manager, presided.

Republic Supply Company. Two new tubular sales representatives have been appointed by Republic Supply: Frank Sanford Jr. at Houston, Texas, and Ralph Bartow at Tulsa, Oklahoma.

T. R. Fullinwider

C. E. Van Loozen

Mission Manufacturing Company. T. R. Fullinwider, former domestic sales manager of Mission Manufacturing Company, has been elected vice president of domestic sales. C. E. Van Loozen was promoted to district manager of the firm's newly created Western district, encompassing California and Canada.

Atlas Bradford Company. Atlas Pipe Inc. of Houston, Texas, and Bradford Supply Company of Bradford, Pennsylvania, have merged to form Atlas Bradford Company, employing over 600 persons. Officers of the new company are W. H. Becker, chairman of the board; Donald W. Mackie Jr., president; J. D. Hayes, vice president and treasurer; and Richard S. Chacon, vice president and secretary.

Hycalog, Inc. Five promotions and three personnel transfers have been announced by Hycalog, Inc. R. R. (Bob) Willis was promoted from assistant to district manager for the well logging division in the Oklahoma district with office in Oklahoma City. W. H. Bradford was made district manager of the Oklahoma-Kansas district, headquartered at Liberal, Kansas.

F. T. Pittman was promoted to sales engineer in Maracaibo, Venezuela. Jess Gilbert, former district engineer, is now district manager of the Oklahoma area, diamond equipment division, located in Oklahoma City. E. W. Furgason was promoted to district manager for the diamond division at Odessa, Texas.

Frank Kruta was employed as sales engineer in the Casper, Wyoming district, with headquarters at Billings, Montana. E. V. Nesbitt, sales engineer for diamond equipment, was transferred from South Louisiana to Oklahoma City. John A. Norwood, district manager for well logging, was transferred to the South Louisiana district from Oklahoma, with headquarters in New Orleans.

Reed Roller Bit Company. Howard Book, senior vice president of Reed Roller Bit Company, recently announced his retirement, after 31 years with the com-

Howard Book

D. R. Thomas

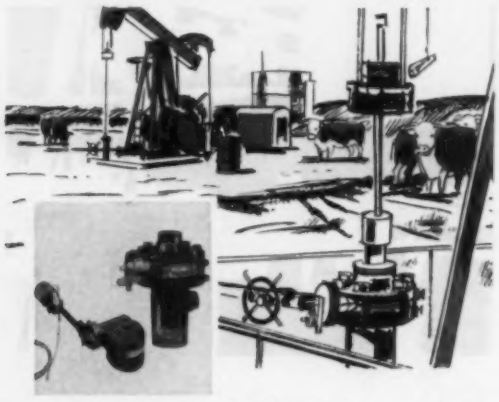
pany. Book will be retained in a consulting capacity and also plans to open an office in Houston as a foreign trade consultant.

Dillard R. Thomas has been named administrative assistant to the sales manager of Reed Roller Bit Company.

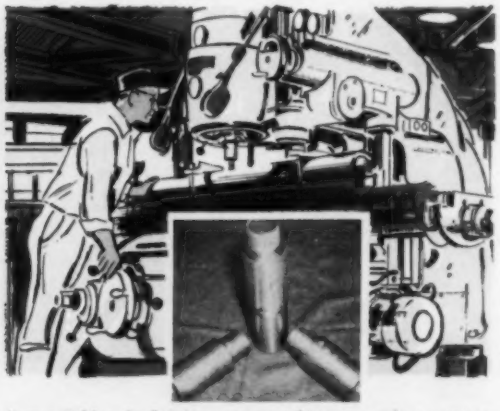
Tyson Smith Company. Keith McCarley has joined Tyson Smith Company as manager of the Corpus Christi district.

ANOTHER CASE OF
HOMCO MANUFACTURING
VERSATILITY

"Only experience guarantees quality in manufacturing... and HOMCO has it!"



Homco Ace-O-Matic Rod and Tubing Revolvers are effective, economical methods of extending the life of rods and tubing on pumping wells. Compact (body diameter: 5-ins. OD) Homco Ace-O-Matic Revolvers fit most carrier bars. Rod revolver is easily installed at any time. Tubing revolver may be installed before tubing is in place or when tubing is pulled for well workover. In addition to giving extra life to the polish rod, rod revolver helps control paraffin. For added safety, tubing revolver has all the necessary pressure control features of a tubing hanger.



Homco Tubing Tool Joints convert tubing to workover strings and protect the tubing string against crushing action of tongs. Designed for fast make-up and break-out, Homco Tubing Tool Joints take all the wear and eliminate the danger of galling regular tubing threads. Machined from heat-treated S.A.E. 4140 steel, Homco Tool Joints are shipped in skidded steel cases to prevent damage. Joints are available as tool joint or coupling type.

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IN QUALITY MANUFACTURED PRODUCTS...
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These proven products from the oil industry's most complete manufacturing and service organization guarantee you top quality tool performance.

Rod and Tubing Revolvers
Tubing Tool Joints
Type "E" Packers
Jet Bypass Valves
Precision Built Steel Subs

Homco Type "E" Packers are ideally suited for high pressure, high temperature completions. Constructed of heat-treated S.A.E. 4142 steel, these packers can be set with a considerable amount of weight which assures that packer will not become dislodged due to high pressure differentials and further insures that a positive seal is maintained. Incorporated in the packer is an automatic bottom which requires 7 to 8 turns to disengage, but may be re-engaged by simply raising the tubing string. This feature means that packer cannot disengage while going in the hole and cause premature setting.

Homco Precision Built Steel Subs are manufactured of high grade, heat-treated alloy steel. Homco Subs are manufactured, machine finished, accurately threaded and gauged to individual requirements to give you the highest quality drilling equipment you can buy. Homco Subs have uniform strength and rigid ruggedness, and are magnaflux inspected to assure that all materials meet Homco's high quality standards. These tools are available as Reducing Subs, Drill Collar Subs, and Drain Subs.

Homco Jet Bypass Valves are used with jet type drill bits to provide auxiliary openings in the drilling assembly above the bit. The valve permits normal fill of pipe while running in the hole thereby reducing the possibility of damage to lost circulation zones because of pressure surges. Valve remains in closed position when circulating and directs all the drilling fluid through the bit. When drilling assembly is retrieved, valve is in open position permitting pipe to drain, thus the swabbing effect of the bit is reduced as it is retracted, and the necessity of pulling wet strings of pipe is eliminated.

WHATEVER YOUR DRILLING EQUIPMENT NEEDS, CALL HOMCO FIRST! Homco's experienced personnel have at their disposal all the required facilities to research and manufacture quality products that more than meet the oil industry's most exacting demands. For further information pertaining to any Homco product, contact your local Homco Supply Store.

HOMCO ALSO OFFERS

HOMCO

HOUSTON, TEXAS — (HEADQUARTERS)

ASSOCIATED A OIL FIELD RENTALS

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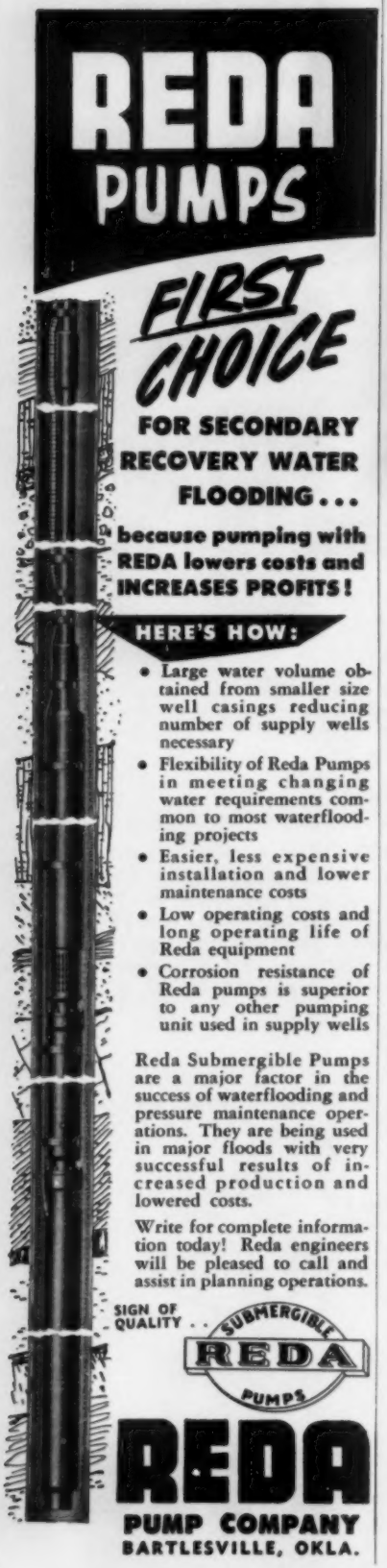
Mexico City, Mexico
Long Beach, California
Maracaibo, Venezuela
Paris, France
Geneva, Switzerland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PUMPS
FIRST CHOICE
FOR SECONDARY RECOVERY WATER FLOODING . . .
because pumping with REDA lowers costs and INCREASES PROFITS!
HERE'S HOW:
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• Flexibility of Reda Pumps in meeting changing water requirements common to most waterflooding projects
• Easier, less expensive installation and lower maintenance costs
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Reda Submergible Pumps are a major factor in the success of waterflooding and pressure maintenance operations. They are being used in major floods with very successful results of increased production and lowered costs.
Write for complete information today! Reda engineers will be pleased to call and assist in planning operations.
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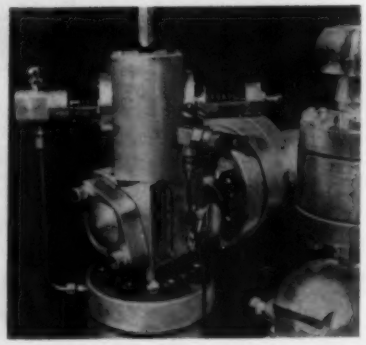
Drilling and Producing EQUIPMENT

Shut-Off Valve



A valve that tests both high and low valve-pressure settings without the well being shut-in, the Hi-Lo Safety Shut-off valve, has been developed by Willis.

The design enables the valve to reset itself with live pressure and to work with pressure rather than against it. It offers further economical advantages by eliminating the need for screw-jack resetting and for auxiliary pressure accumulator.

The valve can be easily adapted for automational remote control and for high fluid level shut-off.

Pressures from 35 to 10,000 psi are safely handled due to the valve's rugged construction. Shut-off is accomplished by a pressure-energized piston with special plastic seats. This piston is actuated from an opening in a stainless steel piston valve with insert seats of the same plastic and adjustable pressure control spring. *Willis Oil Tool Company.*

Circle number (1) on reply card.

Electrical Pump Motors

A new line of squirrel cage Life-Line A motors from 3-75 hp is available from Westinghouse. They are designed for outdoor oil field pumping service.

The motors provide top performance over a wide voltage range. Low magnetizing current assures high power factor even at overvoltage. High starting torque provides positive breakaway even on low voltage under severe loads and in icing conditions.

Both the stator and rotor are designed to handle short time overloads. The temperature rating is 10 deg C below the maximum values of industry accepted standards. Full bar construction is used in the rotor to assure maximum rotor thermal capacity. *Westinghouse Electric Corporation.*

Circle number (2) on reply card.

Multiple Completion Tubing

Because of increased dual and multiple completion practices in the field, National Supply has expanded its line of oil well tubing to include 2⅛ in. OD tubing.

New smaller size is available with integral joint (upset) and threaded and coupled (non-upset). Both types have a nominal weight of 3.40 lb per ft and are supplied in grades J-55 and N-80. *National Supply Company.*

Circle number (3) on reply card.

Pressure Control Pilot

Type TPC (Tubing Pressure Cutoff) pressure control pilots are available from Macco for use in conjunction with gas lift intermitters and flow line controllers or stop cockers as multi-purpose assemblies.

Pilot assembly contains a bourdon tube actuated non-bleed snap-acting pilot valve which may be adjusted to close a motor valve at a predetermined increase or decrease of tubing or casing pressure, independently of the time cycle pilot.

Setting of the bourdon tube pressure cutoff point may be easily adjusted in the field to any desired point within the range of the bourdon tube by simple finger tip manual turning of the pilot turnbuckle. *Macco Oil Tool Company, Inc.*

Circle number (4) on reply card.

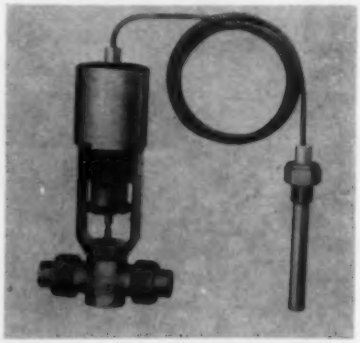
Spray-On Lubricant For Open Chains

A lubricant formulated especially for use on open chains which combines a penetrant, lubricant, and a rust-preventive, is available in 16 oz aerosol container.

Lubricant was developed to work into close-tolerance, internal friction surfaces of open chains to reduce wear and dissipate heat. Free trial can is available upon request. *Whitmore Manufacturing Company.*

Circle number (5) on reply card.

Temperature Regulators For Heaters, Treaters



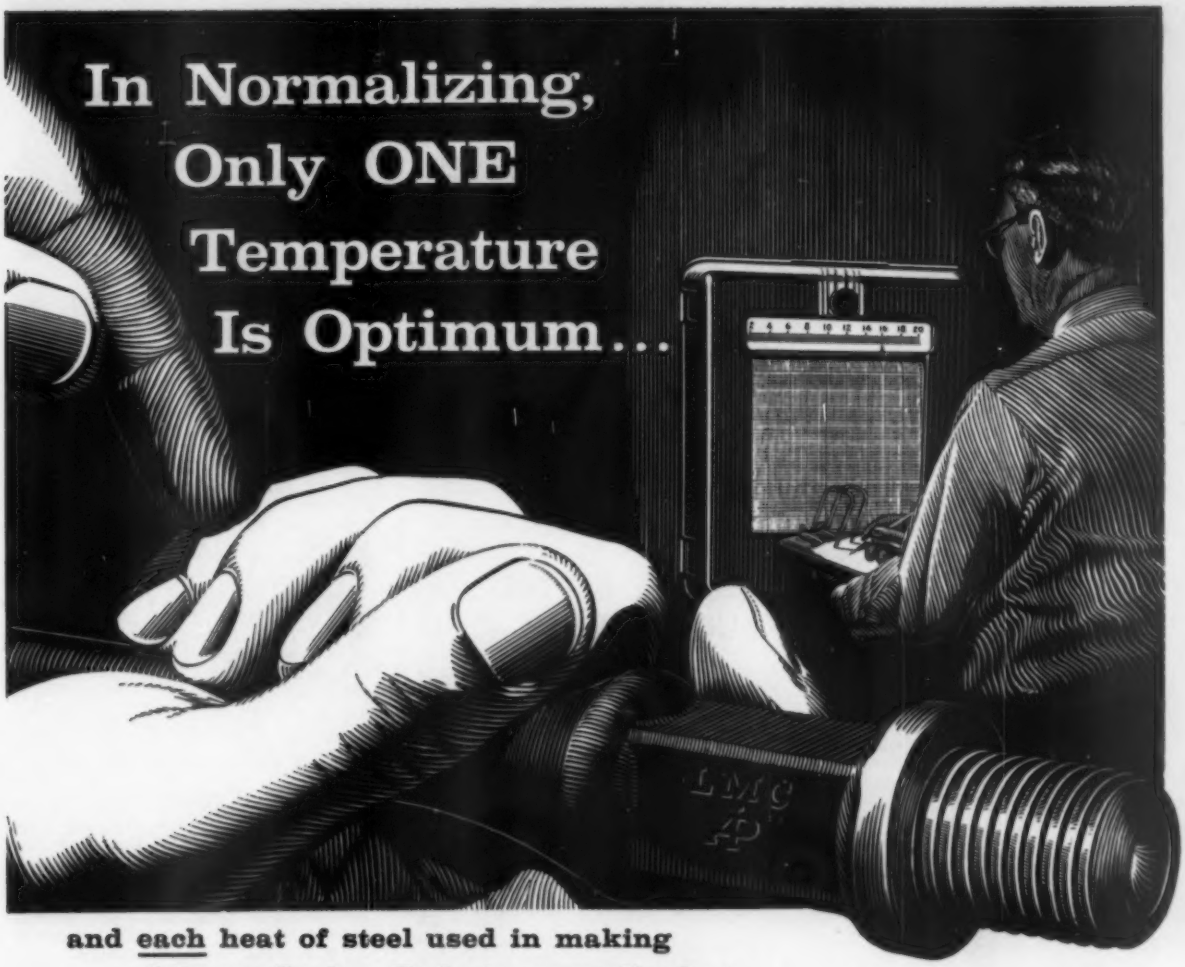
New self-powered temperature regulator especially designed for use on gas fired petroleum heaters and treaters is available from Fulton Sylphon.

Regulator bulb is equipped with a close fitting, tin-plated steel bulb well or socket to facilitate installation. Bulb can also be supplied without the socket.

Regulator valve has a Buna "N" disc, designed for bubble-tight closure. A polished stainless steel valve stem and O ring stem seal made of Buna N provide smooth, leak-free valve operation. A stem cleaner or wiper is provided to protect the O ring seal.

Valve sizes are ½ in. and ¾ in. Temperature range is 110-190 F. *Fulton Sylphon Division, Robertshaw-Fulton Controls Company.*

Circle number (6) on reply card.



and <u>each</u> heat of steel used in making Liberty Sucker Rods is normalized at a "tailored" temperature.

The normalizing temperature vitally affects the physical properties of sucker rods. It is so important that, at Liberty, each heat of steel is carefully tested and analyzed so that the <u>one</u> exact normalizing temperature can be predetermined to assure the maximum desirable physical properties.

Unless this "tailored" normalizing temperature is determined exactly, variation in the physical properties of sucker rods of the same type is possible. This, in turn, could mean that rods in the same production string would have different performance characteristics, and, as every producer knows, <u>a rod string is only as strong as its weakest rod.</u>

That is why Liberty spares no expense or effort to assure that every Liberty Sucker Rod of the same type and size performs exactly as specified. For at Liberty, the goal is not to produce the most sucker rods in the least time, but to produce the <u>finest</u> sucker rods — <u>regardless of time!</u>

FOR EXCELLENT PRODUCTS AND SERVICE
SPECIFY LIBERTY SUCKER RODS AND PUMPING UNITS

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LM-7

Surge Absorber

Hydril Surge Absorbers are available for application on oil well repressuring systems and other pressure applications.

Type "K" Surge Absorbers, which absorb loads caused by fast-closing loading valves, are of the same design used for many years as pulsation dampeners on high pressure oil well mud pumps.

Sturdy, thick-walled steel body, forged steel heads and cast steel valve guard provide maximum protection against possible damage from bumping or rough handling.

Absorber is basically a large-capacity precharged surge chamber which absorbs line fluid under peak pressure loads and exhausts it gently back into the line. Diaphragm at top of chamber can move from one extreme end position to the other without over-stressing or wrinkling.

Diaphragm floats on surface of liquid, gas pressure above diaphragm forces it downward to effect complete displacement of fluid through outlet in lower end of the body. Bottom of diaphragm provided with steel insert which is molded and bonded into synthetic rubber to serve as valve when diaphragm reaches bottom of surge chamber. *Hydril Company.*

Circle number (7) on reply card.

Flange Seal Cover

Covertite, a slip-on, dust-tight seal cover for ASA flanges ranging from ½ in. to 12 in. and pressure ratings from 150 to 2500 lb is made by SEDCO of soft neoprene base elastomer.

It requires no taping and is easily applied and removed. *Service Equipment Design Company.*

Circle number (8) on reply card.

Experience

BUILDS A BETTER SUCKER ROD

W.C. NORRIS SUCKER RODS

Write for complete Sucker Rod Bulletin

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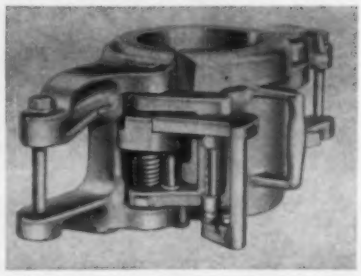
Buy From Your NORRIS Distributor

Side Door Elevators



Two new side door elevators for use with Reed Super Connector Drill Collars are available from Web Wilson.

Designated Type HD-50 and Type HD-150, these elevators are furnished in a wide range of drill collar sizes, and in 50-ton and 150-ton capacities respectively.

Field-replaceable drill collar connectors are supported by these elevators at the drill collar recess. Elevator top bore is specially-machined for this purpose, and a larger bottom bore permits freedom of the drill collar OD below the recess.

Other features include a patented safety latch that automatically locks when the elevator door is latched. With this door in the open position, the new elevators ride perfectly level. Chrome-molybdenum alloy steel is used for the casting, which has a rib-type construction for lighter weight and greater strength. *Web Wilson Oil Tools, Inc.*

Circle number (9) on reply card.

Jet Bypass Valve

A jet bypass valve is available from Homco or Associated Oil Field Rentals.

Purpose of the valve is to provide auxiliary opening in the drilling assembly above the jet bit. The valve, when run with bits having extremely small jets, permits normal fill of the pipe while running in the hole, reducing possible damage to lost circulation zones because of pressure surges.

When the drilling assembly is retrieved, the valve is in its opened position, permitting the pipe to drain. This reduces the swabbing effect of the bit when retracting from the hole, and it eliminates the necessity of pulling wet strings of pipe.

During drilling fluid circulation, the valve is in a closed position, directing all of the fluid through the bit jets. *Houston Oil Field Material Company, Inc.*

Circle number (10) on reply card.

Portable Logging System

A portable logging system developed by Otis logs through the bit on return trips. Ordinarily, a geologist working with regular members of the crew can obtain up-to-the-minute information at the well site.

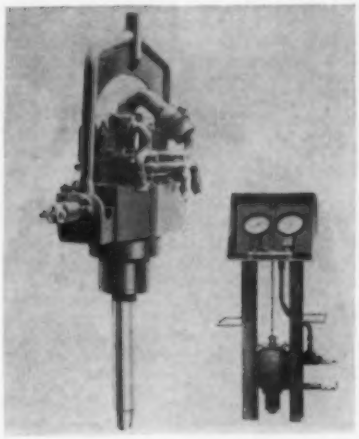
System records self-potential curve, 16 in. and 64 in. normal resistivity curves. Information, including depth data, is recorded on magnetic tape recorder inside the instrument.

There is no need for mud conditioning before logging, and logs can be made immediately after drilling to reduce effect of mud invasion on log, and to study effect of progressive invasion.

Field-tested logging tool consists of two parts. Upper part contains mercury batteries for powering instrument, tape recorder, and timing mechanism. Lower part contains electronics section with flexible electrode assembly attached to lower end of section along with a flexible lead sinker. *Otis Engineering Corporation.*

Circle number (11) on reply card.

Power Swivel



A new power swivel introduced by Hycalog is designed for shallow drilling, deepening of slim holes, coring in cable tool holes and general workover. The swivel is a prime mover for rotating pipe.

The swivel can be operated in a derrick or mast of any design which will support the weight of the drill pipe or tubing and eliminates the need for a rotary table, kelly, and conventional swivel.

The drive consists of integral twin-hydraulic motors powered by oil delivered through hose from a truck or skid-mounted power unit.

Controls permit operation from either the rig floor or at a location well away from the well head. Torque may be held at a pre-set maximum by means of a fluid bypass. *Hycalog, Inc.*

Circle number (12) on reply card.

Diverter Valve

Diverter valve is a three-way, two-position valve for low pressure automatic well testing systems and other applications where it is necessary to divert flow.

New valve has an 8-in. diaphragm and a large flow capacity with 1.77-sq in. opening in a standard 2-in. valve. Pressure drop in the valve occurs in the huddling chamber, protecting the seat and disc from cutting action.

Bonded soft seat provides a bubble-tight seal. All inner parts are removable from the top, and all exposed parts are made of stainless steel. *Garrett Oil Tools.*

Circle number (13) on reply card.

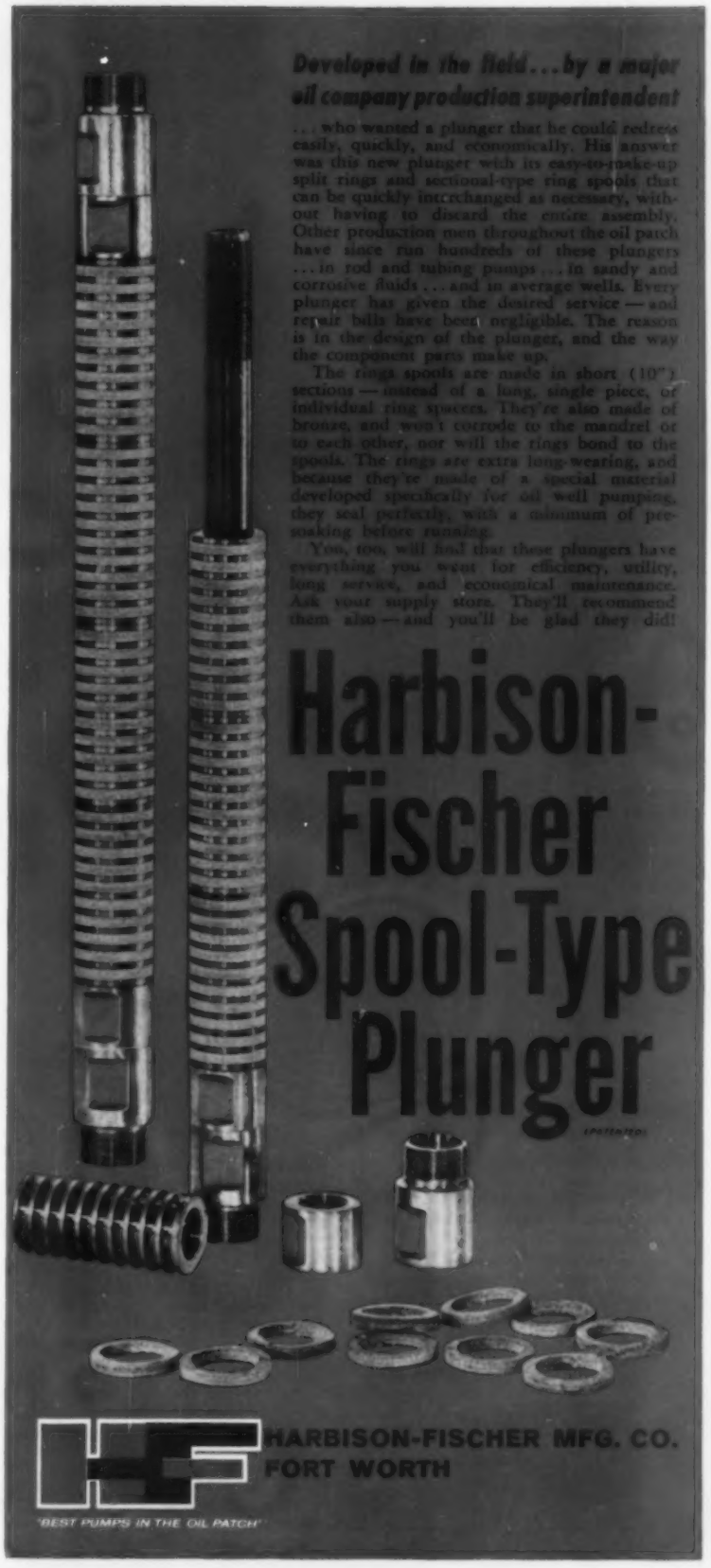
Roller Chain

New roller chain designed and developed to handle heavy loads in extremely difficult operating conditions has been introduced by Atlas Chain.

New chain is designated the Atlas Offset Side Bar Roller Chain. It is designed for use on heavy drives where the going is really severe — such as oil field rigs. This chain is built to provide the sure action of ASA Roller Chain, plus the added clearances to resist faulty articulation caused by rust or accumulation of foreign materials.

This chain is made up of a series of identical links held together with cotter or riveted pins. If elongation of the chain occurs during operation, any link can be easily removed in the shortest possible downtime. *Atlas Chain & Manufacturing Company.*

Circle number (14) on reply card.


Developed in the field... by a major oil company production superintendent
... who wanted a plunger that he could redress easily, quickly, and economically. His answer was this new plunger with its easy-to-make-up split rings and sectional-type ring spools that can be quickly interchanged as necessary, without having to discard the entire assembly. Other production men throughout the oil patch have since run hundreds of these plungers ... in rod and tubing pumps ... in sandy and corrosive fluids ... and in average wells. Every plunger has given the desired service — and repair bills have been negligible. The reason is in the design of the plunger, and the way the component parts make up.
The rings spools are made in short (10") sections — instead of a long, single piece, of individual ring spacers. They're also made of bronze, and won't corrode to the mandrel or to each other, nor will the rings bond to the spools. The rings are extra long-wearing, and because they're made of a special material developed specifically for oil well pumping, they seal perfectly, with a minimum of pre-soaking before running.
You, too, will find that these plungers have everything you want for efficiency, utility, long service, and economical maintenance. Ask your supply store. They'll recommend them also — and you'll be glad they did!
Harbison-Fischer Spool-Type Plunger
HARBISON-FISCHER MFG. CO.
FORT WORTH
"BEST PUMPS IN THE OIL PATCH"

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Another benefit of an Oakite ECP*

One new liquid cleaner does many jobs

OAKITE 202—a new, all-purpose liquid cleaner—is up-to-date proof of just how an Oakite ECP pinpoints the latest research results...gives you more efficient cleaning at less cost.

Whether you spray, mop or brush it on, Oakite 202 is packed with cleaning power. Even when liberally diluted with water, Oakite 202 produces a sudsy solution that cuts fast through grease, grime, caked-on deposits. Yet, it's safe for painted surfaces and fine for brightening up equipment, piping . . . floors, too.

****OAKITE ECP is a detailed Engineered Cleaning Program developed to fit your particular operation under the experienced supervision of your local Oakite man. ECP covers all your cleaning needs.***

For more details write Oakite Products, Inc., 47A Rector Street, New York 6, N. Y.

OAKITE
over 50 Est. 1909 SCIENCE
years' leadership in industrial cleaning

Pumping Unit

A new pumping unit announced by Cook is available in 7 models.

It features a specially-designed gear box and the roller-bearing gear reducer has hardened-alloy helical gears and pinions.

Typical specifications for the JC-5 unit are weight, 1150 lb, and adjustable stroke length from 20 to 30 in. Its double reduction ratio is 39.27, torque rating 16,000 in. lb. Wrist pin is equipped with self-aligning roller bearings. *Cook Manufacturing Company.*

Circle number (15) on reply card.

Hook-Block Has Hydraulic Snubbing

A hook-block with a built-in hydraulic snubbing action, has been developed by National Supply.

The Type 542G250 Universal Hook-block has five 42-in. sheaves grooved for 1⅛ in. or 1¼ in. wire line, and is rated at 250 tons. A simplified articulated connection is provided between the traveling block and the hook elements.

The hydraulic snubbing action cushions the shock and reduces jumping when joints are being broken out. This is intended to prevent serious damage to tool joint threads and reduce the tendency to wobble or swing the table.

The articulated connection provides a universal-joint effect between the block and the hook by means of a crosshead. This is mounted entirely above the lower ends of the block side plates to make the shortest possible overall length. with the hook assembly attached to it by a single, heavy, bronze-bushed crosshead pin.

Rotating on its trunnions, the crosshead permits a 180-deg swing between the block and hook assemblies in the plane of the sheaves, and a 10-deg swing in the plane perpendicular to it. *National Supply Company.*

Circle number (16) on reply card.

Personal Communications Two-Way Radio

A two-way personal radio communications system has been announced by Seiscor. The system features light weight and complete portability.

New system provides two-way wireless communications for industrial applications where small size, minimum weight, and rugged dependability are essential. It is a limited range system for person-to-person communications, utilizing a completely transistorized transmitter-receiver unit weighing less than one pound, including batteries. *Seiscor Division of Seismograph Service Corporation.*

Circle number (17) on reply card.

Drilling-Producing Literature

Buttress-Thread Casing

Six-page folder, Adv. 1103, describes Republic Buttress Thread Casing, the company's first entry into special joints. Folder contains complete technical data including threading data, performance properties, and buttress-thread form and cross-over detail. *Republic Steel Corporation.*

Circle number (18) on reply card.

Recovery Units

Short-cycle adsorption-type hydrocarbon recovery units for moderate pressure gas systems are the subject of a colorful new brochure published by Black, Sivalls & Bryson.

Eight-page pamphlet explains the Dry Frac process in detail, and displays 2, 3 and 4-tower systems — with both open and closed cycle regenerations — through liberal use of informative diagrams. *Black, Sivalls & Bryson, Inc.*

Circle number (19) on reply card.

Maintaining Diesels

A 24-page booklet on diesel engine maintenance has been prepared by Cummins. "Ten Maintenance Steps" tells power users how to increase equipment availability, reduce operating costs, and obtain better engine performance. *Cummins Engine Department.*

Circle number (20) on reply card.

Cast Steel Valves

Complete line of Kerotest cast steel oil and gas field valves and production equipment is described in a 15-page, 2-color brochure. Line includes gate; globe; angle; globe stop check; angle stop check; swing check; pipeline; positive shut-off—double disc, non-lubricated; production — drilling and flow line; general purpose — gage, needle, and diaphragm packless valves; and special valves. Wellhead equipment also is included. *Kerotest Manufacturing Company.*

Circle number (21) on reply card.

Chain and Sprockets

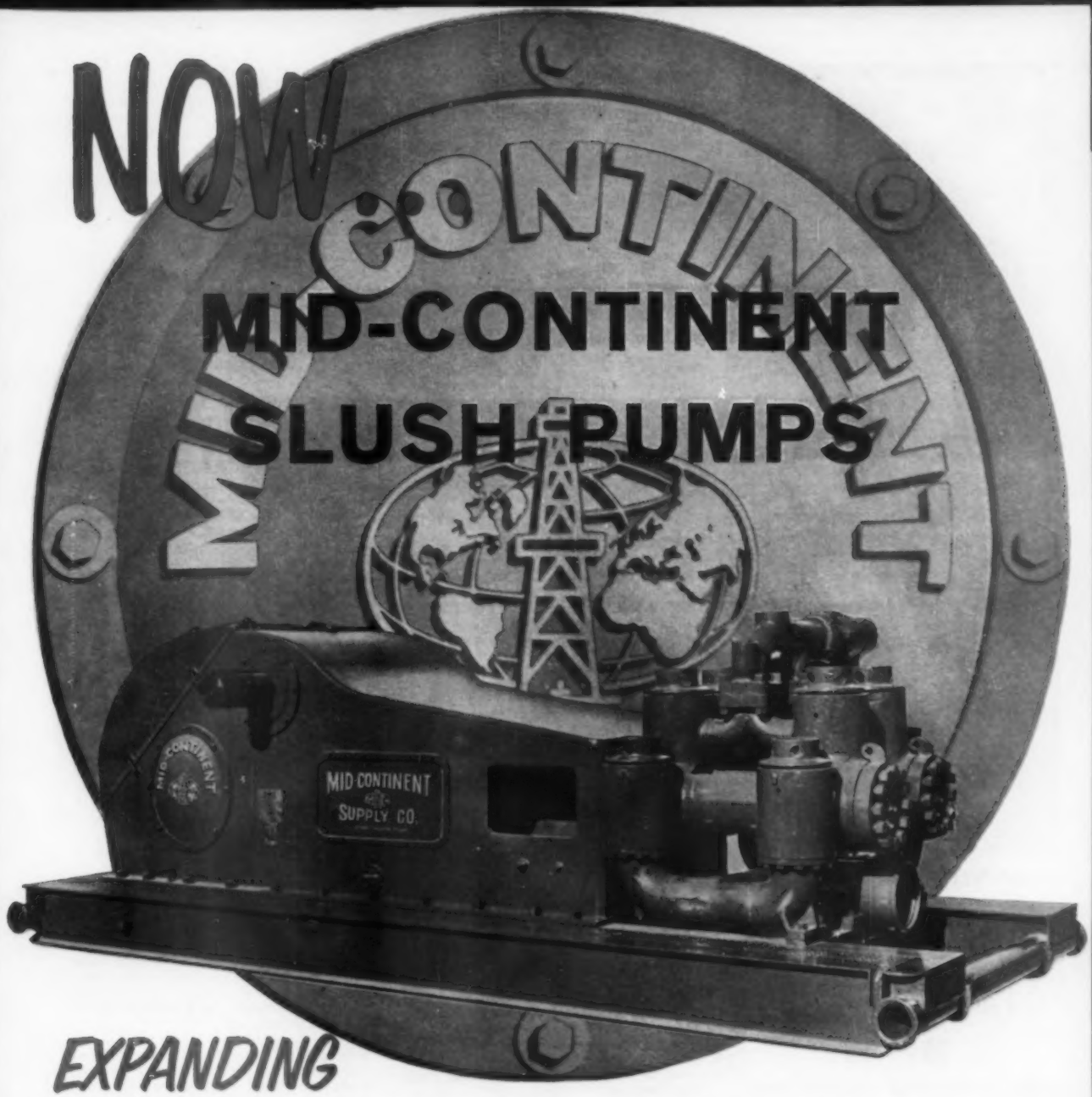
Most extensive line of roller chain and Taper-Lock sprockets ever offered by Dodge Manufacturing Corporation, Mishawaka, Indiana, is presented in 56-page Bulletin A 691.

Expanded line, which includes single strand, double strand, single strand heavy series, double pitch drive, double pitch conveyor, double pitch conveyor with large rollers, and standard attachments.

Photographs and diagrams show construction details. Complete selection data and list prices are furnished, including general information on installation. *Dodge Manufacturing Corporation.*

Circle number (22) on reply card.

NOW MID-CONTINENT SLUSH PUMPS



EXPANDING
the Mid-Continent Line of Drilling Machinery

Since 1938, Mid-Continent Supply Co. has pioneered and field-proved the Emsco Pump throughout the oil fields of the world. Mid-Continent now proudly places its familiar world and derrick emblem on this series of pumps which includes models from 125 to 1000 horsepower capacity. These pumps and parts are 100% interchangeable with the Emsco line. And, Mid-Continent backs these pumps with fast, dependable field service from strategically-located parts and service centers. Call your local Mid-Continent representative today for assistance in selecting a Mid-Continent-Emsco Pump or parts for your drilling requirements.

SP1-0

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B and W Inc.
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for a good cement job

CHANNELING
is defined as . . .

CHAN'NEL.ING 1. To form a channel in; to groove. 2. To convey into or through a channel or channels. 3. Oil Well Drilling. In well cementing, a condition resulting from incomplete removal of fluid, gelled mud and filter cake from behind the casing by the ascending cement slurry.

CHANNELING MEANS . . .

(1) An imperfect primary cement job
(2) Mud left behind the casing
(3) Expensive squeezing
(4) A poor completion

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19706 South Normandie Ave.
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PHONE FAculty 1-2463
146

Portable Rotary Pump

"MP Pumps for Tank Bottom Circulating" is the title of a 4-page bulletin, No. 1009, describing the Duraflex portable rotary pump which is also used for brine disposal, paraffin removal, wash down, rig supply, water charging, and shallow wells.

Bulletin has performance data and prices on 2 of the more popular types of pumps as well as an entire page of extracts from field reports, giving information on actual use and performance. *Marine Products Company.*

Circle number (23) on reply card.

Jet Perforator For Slim Holes

Technical Service Report, T-4501 on McCullough Mac-Jet Perforators, gives a complete description of the new Mac-Jet. It is a small diameter, expendable jet perforator for thru-tubing and slim hole completions.

Unique design features an enclosed firing system. Report includes chart giving specifications and performance data. *McCullough Tool Company.*

Circle number (24) on reply card.

Refraction Seismograph

SIE's P-19 Refraction Seismograph System is described in an illustrated bulletin, which includes specifications. Unit's high and low frequency characteristics render the system valuable for conventional refraction uses, well velocity surveys, and overburden determinations. *Southwestern Industrial Electronics.*

Circle number (25) on reply card.

Surface Active Agents

A 24-page catalog of Surface Active Agents has been published by Onyx Oil & Chemical.

Each product is described by trade name, active ingredient, percent activity, physical state, general use, specific applications, and properties. Products are divided into three general classes: anionic, cationic, and non-ionic. There is a 2-page section explaining the chemistry of each of these groups. *Onyx Oil & Chemical Company.*

Circle number (26) on reply card.

Pipe Joint Sealer

Two-page brochure, containing free samples, describes industrial and commercial applications for Tape-Seal, a chemically-inert plastic intended to provide positive leak protection for all types of threaded pipe connections even under extreme conditions of temperature, pressure, or corrosive atmosphere. *Friesland Plastics Company.*

Circle number (27) on reply card.

Angle Valve

Features and specifications of the Jerguson No. 74 universal angle valve for liquid level gages or instrument piping and general use are described and illustrated in new Data Unit No. 361. The advantages of a single piece forged body and bonnet flange, simplified OS&Y bolted bonnet, and reciprocating stem are combined in one valve. *Jerguson Gage and Valve Company.*

Circle number (28) on reply card.

Waterflood Equipment

Illustrated brochure describing waterflooding and disposal equipment presents the different types of equipment suitable for various operating conditions and offers suggestions for correct equipment selection. *Jones & Laughlin Supply Division.*

Circle number (29) on reply card.

Heat Exchanger

Revised shell and tube heat exchanger catalog with 15-pages in 2 colors presents complete data on Young's copper base alloy, steel and stainless steel fixed tube bundle heat exchangers.

It includes single-pass, 2-pass and 4-pass models for cooling water and oil in fresh or salt-water applications as well as specially-engineered heat exchangers for heating or cooling liquids and gases.

Illustrated catalog 1258A lists tables showing pressure ratings and material specifications for steam service heat exchangers. Construction features, model identification, and a 6-step set of instructions explain the selection of heat exchangers. *Young Radiator Company.*

Circle number (30) on reply card.

Special Fabrications

Twenty-page descriptive brochure covers specialties and special fabrications of Joe Stine, Inc.

Among products described are "Lightning" rig skidding equipment, a pipe and kelly straightener, various hydraulic jacking mechanisms, dual-purpose bins serving for transportation as well as pipe racks, standard equipment such as mud tanks and systems (including special clean-out arrangements for tanks), work benches, tool houses, rig-up for export, stiff-leg derricks, and other items. *Joe Stine, Inc.*

Circle number (31) on reply card.

Natural Gas Engines

Complete line of Caterpillar natural gas engines is described in 8-page booklet 20173.

Booklet traces development of natural gas engine at Caterpillar, shows model views, specifications, and fuel consumption curves of current models. It contains photographs and job stories illustrating actual performance. *Industrial Engine Plant, Caterpillar Tractor Company.*

Circle number (32) on reply card.

Geophysical Data Processing

An illustrated bulletin describes the SIE MS-12 GeoData geophysical data processing system, which handles both SIE FM and direct-recorded AM magnetic tapes to produce a pen-recorded time cross-section on paper which can be photographically reproduced.

These time cross-sections can be isopached or set to a desired reference plane for presentation in geologically oriented form. Corrected information on these final records is also recorded on magnetic tape for other uses, such as making additional cross-section with other filtering or mixing. *Southwestern Industrial Electronics.*

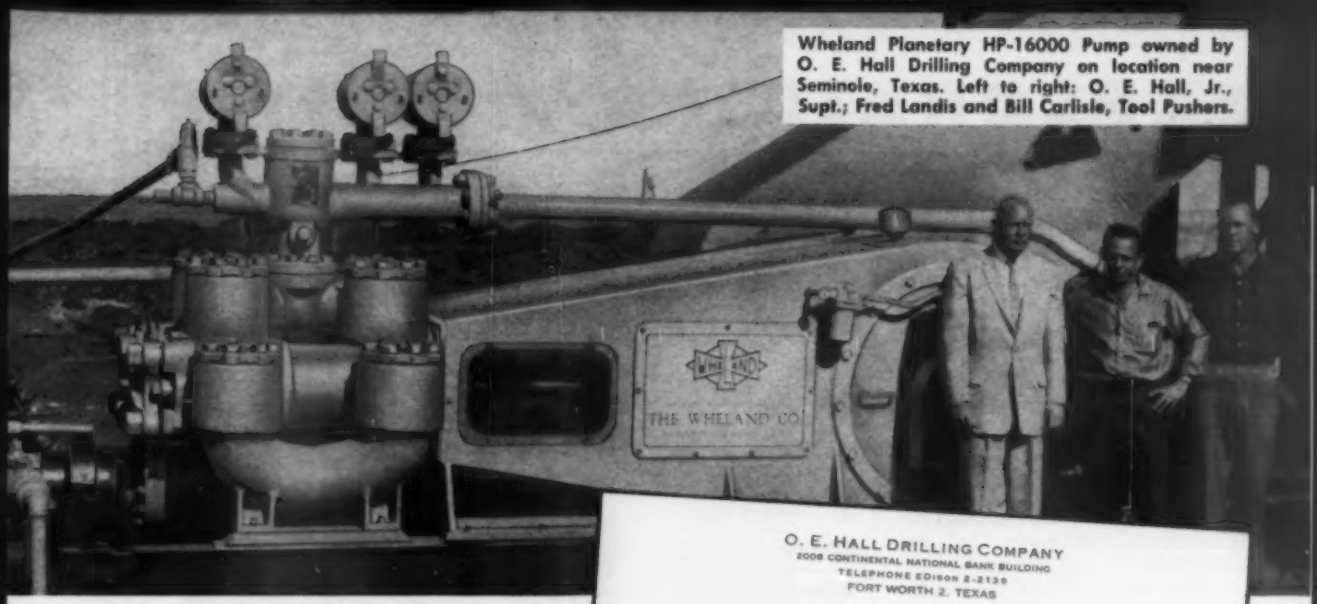
Circle number (33) on reply card.

Arizona Geological Map

Geological map of Gila County has been published by the Arizona Bureau of Mines at the University of Arizona and is now ready for distribution. It has a scale of 1 in. to 375,000 in.

In addition to depicting detailed geological conditions in Gila County, it also shows topography and cultural features, such as roads and towns. Map is in color and includes an explanatory guide to the location of different types of sedimentary, metamorphic and igneous rocks, and a color key showing the sources of the geological data included on the map.

Circle number (34) on reply card.



Wheland Planetary HP-16000 Pump owned by O. E. Hall Drilling Company on location near Seminole, Texas. Left to right: O. E. Hall, Jr., Supt.; Fred Landis and Bill Carlisle, Tool Pushers.

"... the pump has improved our operation ...we will be happy to recommend it."

O. E. HALL, Jr.

WHELAND PLANETARY HP-16000 PUMP

Duplex Power Slush Pump

7¾"x16", 600 HP at 65 RPM

O. E. HALL DRILLING COMPANY
2008 CONTINENTAL NATIONAL BANK BUILDING
TELEPHONE EDison 2-2139
FORT WORTH 2, TEXAS

February 16, 1960

The Wheland Company
Signal Mountain Road
Chattanooga, Tennessee

Mr. Gordon L. Smith, Jr.
Manager Rotary Drilling Equipment Sales

Dear Mr. Smith:

We thought you would be interested to know how pleased we are with the performance of our Wheland Planetary HP-16000 Pump. It is the smoothest running pump we have seen. The big gear reduction makes possible such a small sheave and the pump pulls very easily. We are also impressed by the compactness of the gear cartridge and the smooth performance of the new circular crosshead. In the several wells we have drilled thus far the pump has improved our operation in terms of penetration rate and savings in bits. Also has exceeded our expectations.

All of these wells have been located in West Texas. We operate our rigs throughout the Permian Basin covering a depth range of 4, 500 feet to 12, 500 feet with modern equipment.

We want to commend The Wheland Company for stepping forward with this improved design in slush pumps, and we will be happy to recommend it.

Very truly yours,

O. E. HALL DRILLING COMPANY
O. E. Hall Jr.
O. E. Hall, Jr.
Midland, Texas

WHELAND

ROTARY DRILLING MACHINERY

THE WHELAND COMPANY

CHATTANOOGA, TENNESSEE, U.S.A.

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EXPORT DISTRIBUTORS: LUCEY EXPORT CORPORATION—233 Broadway, New York 7, New York—Broad Street House, London, E. C. 2, England.

EXPLORATION ACTIVITIES

Parker Elected President Of Geologists Association

Ben H. Parker, vice president and director of the Frontier Refining Company, Denver, will become the 44th president of The American Association of Petroleum Geologists April 28. Serving with Parker on the 1960-61 executive committee of the world's largest geological organization will be Lewis G. Weeks, consulting geologist, Westport, Connecticut, as past-president; Frank B. Conselman, consulting geologist, Abilene, Texas, as vice president; George V. Cohee, U.S. Geological Survey, Washington, D.C., secretary-treasurer; and Grover E. Murray, professor of geology at Louisiana State University, Baton Rouge, the present editor.

ALASKA

Field Survey Planned In Umiat, Gubik Areas

British Petroleum Exploration Company (Alaska) Inc. plans to undertake a geological field survey with three geologists during the summer of 1960.

Company has been granted leases on about 50,000 acres in the Umiat region and has options on another 120,000 acres in the Umiat and Gubik areas, plus a small area in the Copper River Basin in the south.

British Petroleum has also taken an interest in a deep test well being drilled by Paul G. Benedum in the Nulato Basin, adjoining the Yukon River in Western Alaska.

Shell Secures Rights To 450,000 Acres

A five-year development contract for Shell Oil Company to explore for oil and gas on 450,000 acres in Alaska was approved by the U. S. Government.

Under the contract, Shell is required to drill at least three exploratory wells and spend a minimum of $950,000. The company will relinquish half the acreage before 1964.

The 450,000 acres are located about 90 miles southwest of Bethel, on the northern coast of Kuskokwim Bay.

This is the eighth development contract currently active in Alaska. It is part of about 4,600,000 acres within the six major areas being explored. A total of 13 companies will participate in development.

BELGIUM

Bataafse Plans Study Of Complicated Structure

Bataafse Petroleum Maatschappij N.V., The Hague has applied for an oil and natural gas exploration and development permit on 263,000 hectares in Southern Belgium. Company is one of the Royal Dutch/Shell group.

Region has a particularly complicated subterranean structure, and there has never been a systematic search for oil there. It comprises the southern part of the province of Hainaut, the center of the province of Namur, and the western parts of the provinces of Liege and Luxembourg (Belgium).

A scientifically conducted survey of the area will start as soon as possible.

BOLIVIA

Atlantic Acquires Interest In 1,250,000 Acre Concession

Atlantic Refining Company has exercised its option to acquire an 80 percent interest in Bolivian oil concessions covering approximately 1,250,000 acres, which are held by Drilling and Exploration Company. Both are Dallas companies.

Concessions are in Zone 1 of the Petroleum Reserve Area in Bolivia. A 20 percent interest will be retained by Bolivian Petroleum Corporation, a subsidiary of Drilling and Exploration.

Atlantic conducted a year of extensive exploration work on the concessions, which consisted of an interpretation of aerial photography, surface geology, gravity meter, and seismic surveys. Under the terms of the purchase agreement, Atlantic will drill one exploratory well to test the Devonian formation if encountered, or to a total depth of 11,000 ft.

Concession where the test well will be drilled covers a portion of the provinces of Ichilo and Gutierrez in the Department of Santa Cruz. It is situated in the vast sedimentary basin off the east flank of the Andes Mountains. The same geologic formations exist that are productive in major oil fields to the south.

Location of the test well will be 60 miles north of the city of Santa Cruz and some 180 miles east of the city of Cochabamba.

BRITAIN

Anticline Investigated Near Isle of Wight

A marine seismic survey in the waters off the southwest coast of the Isle of Wight has been completed. The British Petroleum Company investigated the nature of an anticline to trace the shape and size of the seaward part, hoping to find oil-bearing formations.

CANADA

Exploratory Test Staked At Buffalo Head Hills

Drill site for an exploratory test well at Senex Creek in the Buffalo Head Hills area has been staked by Crusade Petroleum Corporation, Ltd., Home Oil Company, and Alminex Ltd. Site is about 60 miles southeast of Fort Vermilion on L.S.D. 6-33-99-7W5. Well will be drilled to about 4200 ft as a Pre-Cambrian test.

Acreage was acquired by the group under a farmout agreement from Crusade and associates. The well, White Rose et al Senex Creek 6-33-99-7 will be operated by the Canadian oil companies.

Gas Discovery Confirmed In British Columbia

Pacific Petroleums Ltd. has confirmed a new Mississippian gas discovery in the Pocketknife area of northeastern British Columbia.

The well, Hudson's Bay Pocket Knife c-37-L flowed gas in three drillstem tests as follows: Test No. 1, 7,400,000 million cu ft per day; Test No. 2, 8,300,000 cu ft per day; and Test No. 3, 3,000,000 cu ft per day.

Third test also flowed water at an estimated rate of 600 bbl per day. Drillstem tests cover a 294 ft interval in the top of the Mississippian Rundle formation, which was encountered at 4979 ft.

Discovery is located on Hudson's Bay Oil & Gas Company's Permit No. 966, which comprises 24,581 acres. Currently the well is being drilled to greater depths.

INDIA

Three Wells Completed At Nahorkatiya

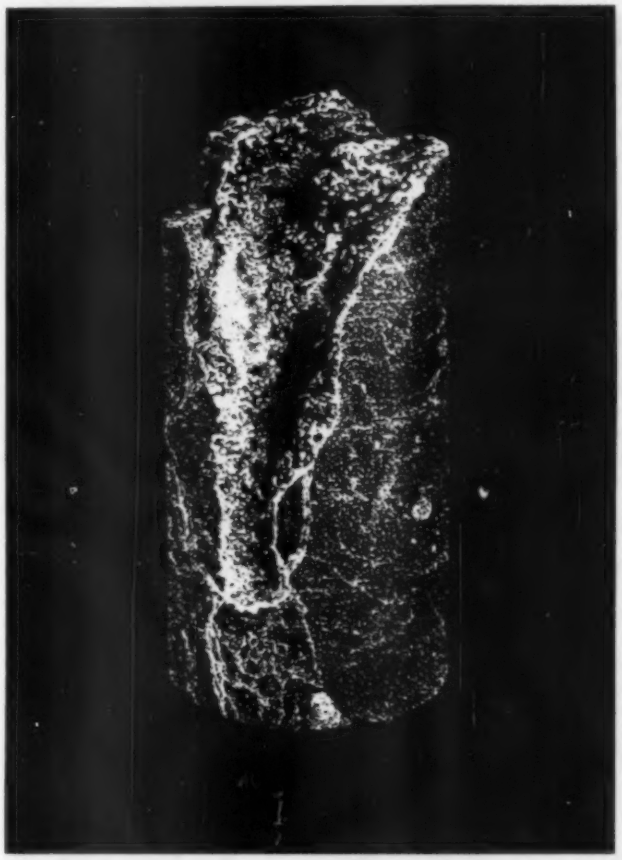
All three wells drilled at Nahorkatiya in 1960 have proved to be successful. This makes a total of 66 wells drilled by Assam Oil Company drillers at Nahorkativa and Moran, the Oil India areas in Upper Assam.

Wells No. 55 and 56, which were spudded in at Nahorkativa recently, are progressing satisfactorily. Preparations for drilling Well No. 57 are underway.

JAMAICA

Complete Exploration Rights Granted After Evaluation

Government of Jamaica, West Indies, has granted 46 oil prospecting licenses covering all of the island and its terri-



Free sets of full-color reproductions of core samples, suitable for office decoration, are available. Request must be made on your company letterhead, and include name of this magazine and date of issue. Address — Core Lab, Box 10241, Dallas 7, Texas.

Underneath Michigan

Trenton Limestone, Albion Area, Michigan: producing depth, 3923 feet; permeability, 2992 millidarcys; porosity, 6.78%; residual oil, 10.4%; total water, 45.2%.

The successful care and handling of this reservoir began with core analysis — *the very taproot of formation knowledge* — performed by the industry's best reservoir technicians using the industry's finest specialized facilities . . . For the client, it was a sound, *realistic* approach to establish a technical foothold for the development and financial events which follow — completion procedures, fluid studies, special producing problems, long-range evaluation, and probable secondary recovery.

This sample of Trenton Limestone represents approximately one two-millionth of Core Lab's reservoir knowledge. Every foot of this experience goes into every job.

CORE LABORATORIES, INC.

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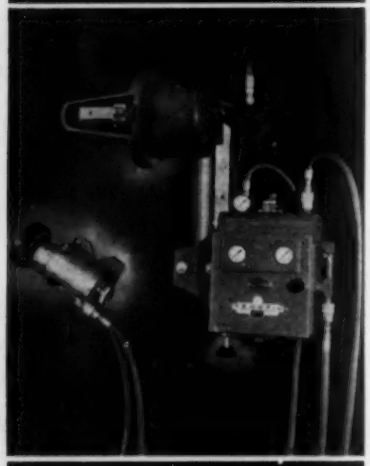
The NEW GEODRIL® AUTOMATIC DRILLER



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The GEODRIL Automatic Drilling Control was developed, tested and proved in the field by The Geograph Company, manufacturers of the internationally accepted Geograph Mechanical Well Logging Recorder.

The new, automatic GEODRIL control has many outstanding features and offers the drilling contractor dependability, economy and safety.

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When you drill your next well, specify the NEW GEODRIL Automatic Driller for maximum drilling efficiency. For additional information, contact your nearby Geograph Oil Field Services office.

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torial waters to Jamaica-Time Petroleum, Inc.

Issuance of these licenses is the culmination of many months of intensive evaluation of the oil and gas potential of the island by the geological and geophysical staff of Jamaica-Time.

Under terms of the agreement, the company plans an additional 14-month geophysical and geological program. Then during the following 20 months, five deep tests will be drilled. One of these must test Cretaceous sediments.

During the past several months, all of the data of the Jamaica mines department and geological survey department, plus information from other companies was reviewed and studied.

Geophysical information indicates excellent structural conditions. Gas seeps have been analyzed, and micropaleontologists will conduct further field studies, with particular emphasis on large reservoir shales.

CALIFORNIA

Wildcat Operation Scheduled In Los Angeles County

Blackwell & Sunde Company, Long Beach, California, will begin drilling operations for a wildcat well in East Los Angeles. Well is a joint venture for Nordon Corporation, Ltd., and Steele Petroleum Company of Phoenix, Arizona.

Elevation of the well is 165 ft above sea level. It is located on the SW quarter of Section 6, Township 2 South, Range 12 West, San Bernardino B&M Los Angeles County. Drilling site is directly across from Home of Peace Cemetery.

California May Agree With U. S. on Offshore Title

An agreement between the State of California and the United States Government for development of offshore oil and gas areas where ownership is being disputed may be reached soon.

There has been some difference as to where the state boundary should be, since the state maintains that a small group of islands is the shoreline and the federal government takes the position that the shoreline is on the inside of the bay in the area.

Exploratory Well Drilling In San Joaquin County

Christiana Oil Corporation is drilling its fourth scheduled exploratory well on its 55,000 acre gas prospect at Manteca, California. It is 60 miles east of San Francisco and six miles from the Vernalis gas field, in Section 17, Township 2 South, Range 7 East, San

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Joaquin County. Designated No. 1 Antonini, it will be drilled to the Tracy sand at approximately 5500 ft.

First exploratory well has also been started on 5700-acre marine license off the west coast of Trinidad, which is owned by Kern Trinidad Oil Fields, Ltd. and in which Christiana has a 15 percent net profit interest. Well is 5000 ft offshore.

Union Will Develop 22 Sites in Orange County

Union Oil Company will begin immediate development of 22 drilling sites on its extensive Stearns mineral fee properties in the Orange County section of the Los Angeles Basin.

Program is being undertaken at this time because of rapid encroachment on the property by home and industrial development.

Successful Well Completed In New Lakeside Field

Tidewater Oil Company reports successful completion of KCL 15-2 well in its newly-discovered Lakeside field in California's Southern San Joaquin Valley for initial production of 232 bbl per day of clean, 34 gravity oil on a ⅜-in. choke.

The well is producing from a Stevens sand interval between 8873-8941 ft. Location is 330 ft south and east of the west quarter corner of section two, township 31/26, Kern County.

First production in the field was obtained in late November by Tidewater's KCL 86-3, 900 ft southeast, which established a flow rate of 700 bbl per day of clean oil on a drill stem test. This well, which logged 99 ft of upper Stevens sand, is currently drilling ahead in the Stevens section at 11,400 ft for possible deeper production.

Tidewater will immediately spud a step-out well, KCL 75-3, 1320 ft due west of KCL 15-2, and plans to keep two rigs busy developing the new fields. A solid block of 3000 acres leased in the area belongs to Tidewater, and it was leased from Kern County Land Company.

TEXAS

Conglomerate Formation Pay Struck in Jack County

Bayview Oil Corporation and Exploration Surveys, Inc., have announced a new pay discovery with the completion of the H. C. Gilmore No. 3 George Dedrick Survey, in southwest Jack County, Texas. The well is approximately 12 miles south of Graham.

Production is from the interval between 4098 to 4103 ft in the Conglomerate formation.

On a drill stem test of the Conglomerate zone from 4100 to 4108 ft, gas surfaced in five minutes with an estimated volume of 196,000 cu ft per day. Total fluid recovered was 755 ft of free oil, 30 ft of heavily oil cut mud, and 10 ft of salt water. Initial flowing pressure was 95 lb and final flowing pressure was 220 lb.

Initial shut in pressure was 2005 lb and final shut in pressure was 1970 lb.

Casing, 5½ in., was set to a depth of 4268 ft with 150 sacks of cement. The well was perforated from 4098 to 4103 ft, and on a potential test flowed 80 bbl of 44 gr oil per day through a 13/64-in. choke. Flowing tubing pressure was 600 lb, and had a gas-oil ratio of 900 to 1.

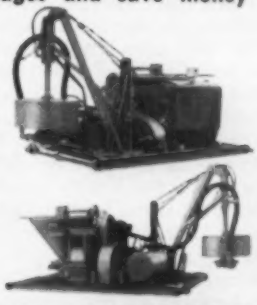
Last July Bayview announced the new field discovery with the completion of the H. C. Gilmore No. 3 in the Mississippian formation, one mile southwest of Finis in Jack County.

Bayview confirmed the field with its Gilmore No. 1-A and No. 2, both oilers. Shows in the Conglomerate section of previous wells have now been proven with the No. 3 Gilmore as a new pay discovery. This constitutes a multi-pay discovery, and application has been made for a new field designation of Bayex Conglomerate.

New Mudmixer Makes Other Mixing Methods Obsolete and Costly

Compare Thompson's field proved advantages and save money

Automatic feed and mixer gives close control of dry muds and chemicals (except caustic soda) and mixer delivers mud to system thoroughly mixed. Actual field tests have proven an *increase in jel yield of 15% to 30%* over hand feed and jet mixing methods. Thompson Mud and Chemical Mixer is a complete unit with pump and power.



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What's doing in DRILLING

Latest Drilling Developments Discussed by Authorities

Authorities in their fields presented latest reports on several interesting and important developments in drilling at the Southwestern District meeting of the division of production of the American Petroleum Institute in Dallas recently. Discussions included plans for drilling to the Mohorovicic Discontinuity, optimism for future development of turbodrilling, and a comparison of results between air-rotary drilling and air-rotary results.

Intensive analytical work preparatory to the drilling of a 31,000 ft well in the open seas was described by Willard Bascom, of the National Academy of Sciences, Washington, D. C. He is a technical coordinator of a project to drill to the Mohorovicic Discontinuity, a geological marker bed which underlies most of the earth's surface at depths from 30,000 to 90,000 ft.

Project, which is being carried on jointly by the Academy of Sciences and the National Research Council, is expected to yield valuable information on the earth's surface at extreme depths. He indicated a belief that problems connected with holding the drilling ship in position, and stresses in the long drill stem, were well on the way to solution.

Hughes Tool Study Shows Progress in Lowering Drilling Costs

Optimum variable bit weight and rotary speeds is a mouthful but is descriptive of the two-year study by Hughes Tool and the AAODC to lower drilling costs. E. M. Galle, Hughes researcher, reported at Southwest District API meet that as much as 25 percent has been cut from normal drilling costs by following experimental data on bit weight and rotary speeds during life of a bit. Generally, slow speeds and light weights are used for a new bit. Weight and speeds are increased during bit life to obtain maximum footage and desired penetration, thereby reducing round trips. Ultimate objective is to provide a few curves for toolpushers to use according to bit type, size and area drilled. It is expected that this manner of "engineered" drilling should show a reduction of about 10 to 12 percent.

W. E. Bingham, Shell Oil Company, Midland, Texas, claimed reason for optimism that the turbine method of drilling would ultimately offer a means of drastically reducing drilling costs. Relative success and prominence of turbodrilling in Russia was more apparent than real, due to the difference between Soviet and American economic systems and the fact that conventional rotary drilling techniques were not as advanced in Russia as they are here. He felt that further progress in the United States would be made, however, in modifying the drill and developing bits capable of withstanding great weight and speed.

Performance of air-hammer drilling in the Permian Basin was compared with air-rotary results by H. F. Downs, Technical Service Company, Midland. He concluded that the air-hammer system promised a doubling of penetration rates, less hole deviation, and increased bit footage. He described the use of air-hammer drilling on five Delaware Basin wells in which rates of penetration ran from one and one-half to three times as great as conventionally drilled wells.

Record Bidding Indicates Continued Offshore Activity

Federal government has accepted more than $285,000,000 in high bids from oil companies for competitive oil and gas leases offshore from Louisiana and Texas.

About $192,000,000 of this amount was for leases located far from shore in Zone 4, the federal zone, off Louisiana.

There were 173 leases sold in the sale. Deepest water in any of the leases was 300 ft, and more than 125 leases were sold in what is considered to be wildcat territory. These leases must be drilled within five years before title is awarded.

Bids broke many previous records and indicate continued interest in offshore exploration and drilling, mostly by companies who had previously been operating in this area. Amount of the bids astounded John Rankin, manager of the U. S. Bureau of Land Management office in New Orleans, as they far exceeded his expectations.

Louisiana coastal submerged lands, involving 300 tracts comprising 1,500,000 acres, brought an aggregate bid of $249,248,616.

Mobile Platforms Withstand Battering Successfully

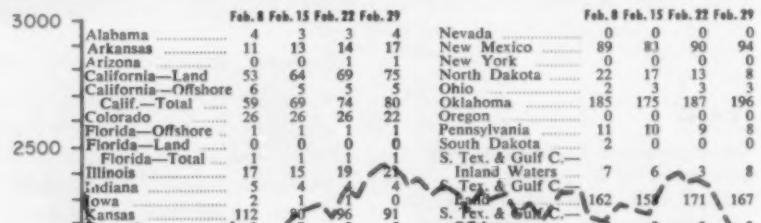
No major failure of mobile drilling platforms occurred offshore from Louisiana after nine days of severe battering from high seas and winds. Waves up to 25 and 30 ft, lashing the installations for two days in succession, failed to cause any extensive damage during a recent storm.

Some damage to floating equipment was reported, however, as one 60 ft supply boat was swamped.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oil Well Drilling Contractors by Hughes Tool Company.

	Feb. 8	Feb. 15	Feb. 22	Feb. 29
Alabama	4	3	3	4
Arkansas	11	13	14	17
Arizona	0	0	1	1
California—Land	53	64	69	75
California—Offshore	6	5	5	5
Calif.—Total	59	69	74	80
Colorado	26	26	26	22
Florida—Offshore	1	1	1	1
Florida—Land	0	0	0	0
Florida—Total	1	1	1	1
Illinois	17	15	19	21
Indiana	5	4	4	4
Iowa	2	1	1	0
Kansas	112	80	96	91
Kentucky	9	7	5	5
North Louisiana	34	30	27	25
South Louisiana—				
Inland Waters	115	120	111	125
South La.—Land	98	96	94	85
South La.—Offshore	57	49	58	47
Louisiana—Total	304	295	290	282
Maryland	0	0	0	0
Michigan	34	32	34	37
Mississippi	72	80	79	69
Missouri	1	2	1	1
Montana	8	11	12	12
Nebraska	17	17	24	23
Nevada	0	0	0	0
New Mexico	89	83	90	94
New York	0	0	0	0
North Dakota	22	17	13	8
Ohio	2	3	3	3
Oklahoma	185	175	187	196
Oregon	0	0	0	0
Pennsylvania	11	10	9	8
South Dakota	2	0	0	0
S. Tex. & Gulf C.—				
Inland Waters	7	6	3	8
S. Tex. & Gulf C.—				
Land	162	158	171	167
S. Tex. & Gulf C.—				
Offshore	0	0	0	0
North & East Texas	141	143	153	131
West Central Texas	205	198	192	194
West Texas	82	84	96	95
Texas—Total	597	589	615	595
Utah	26	27	29	28
Washington	1	1	0	0
West Virginia	3	3	3	4
Wyoming	58	54	50	54
Total U. S.	1678	1618	1683	1660
Western Canada	235	242	255	248
Eastern Canada	4	4	4	4
Grand Total	1917	1864	1942	1912



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A combination tester and locked open by-pass operated by vertical movement of drill pipe... Aids in the easy, rapid descent of the string and in the elimination of formation and packer damage ... provides positive indication when tool opens.

EXPANDING SHOE WALL PACKER ASSEMBLY

Minimizes hole drag through use of smaller packer... Results in fewer misruns, less rubber left in hole, and more dependability, especially in oversize holes... Easier packer release; pulling or jarring is minimized.

BOURDON TUBE GAUGE

Unlike some recording gauges that incorporate packing, the Halliburton Bourdon Tube Gauge is virtually friction-free, for unequalled accuracy and better results in formation testing.

VR SAFETY JOINT

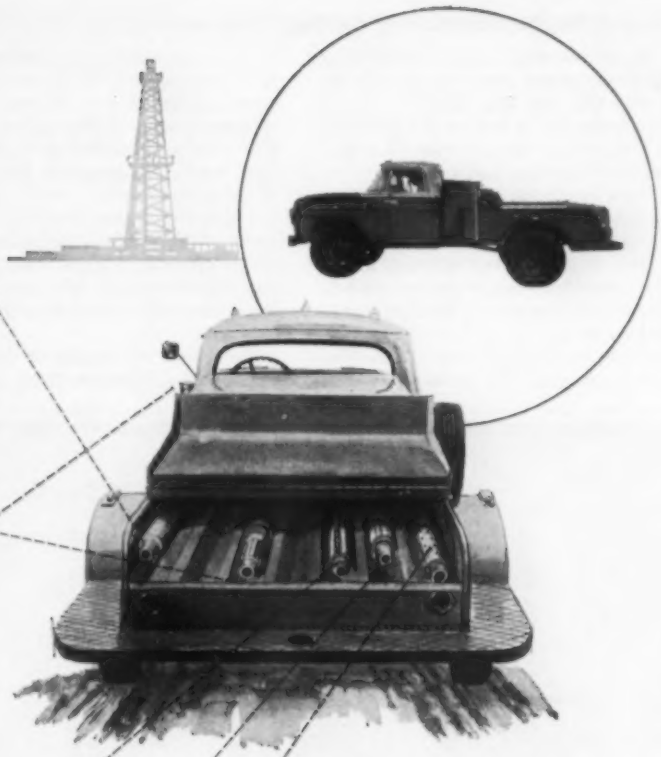
Assists in the removal of drill pipe and testing tools in case either packer or anchor becomes stuck . . . Built-in by-pass provides pressure equalization to aid in unseating packer.

HYDRAULIC JAR

Puts the "striking power" of hydrostatic pressure to work in jarring loose stuck packers and drill pipe... saves strain on rig and expensive round-trip time... Eliminates rotation and mechanically operated tripping mechanisms.

PERFORATED ANCHOR

Built to withstand the heaviest loads encountered in formation testing... Also acts as screen to help prevent plugging of bottom hole choke.



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Record Depth Established Setting 13⅜ In. Casing

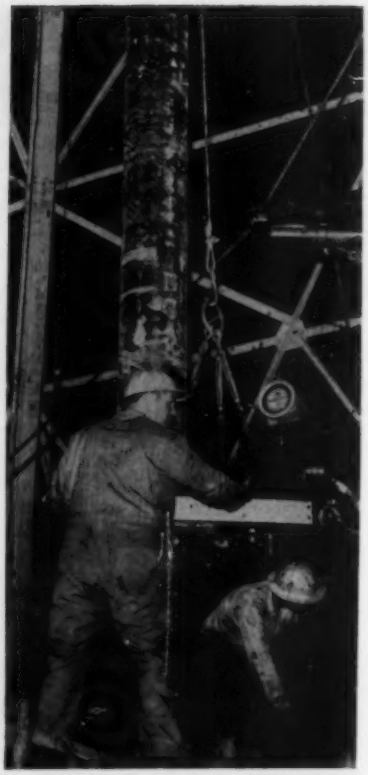
A new record depth of 10,487 ft for 13⅜ in. casing was set recently by Union Oil and Gas Corporation of Louisiana. String was set in the Ursule A. Simon oil well in the Le Leux field south of Crowley, Louisiana.

This string was over 2000 ft deeper than the previous record depth for 13⅜ in. casing.

The 18,000 ft well is being drilled into a formation where the bottom-hole pressure is expected to be in excess of 15,000 lb per sq in. Last August, on the Adams No. 1, Union Oil decided a long string of 13⅜ in. surface casing would be advantageous in the next well. A long string of 13⅜ in. allows subsequent strings of 9⅝ in. and 7 in. to be used to case off deeper formations. By so doing the operator has a better opportunity to complete the well to the projected depth.

Protection string consisted of 261 joints of 13⅜ in. casing calculated to weigh 756,000 lb in air. The load, reduced by buoyancy, float, and friction, did not exceed 500,000 lb on the weight indicator.

To reduce the weight of the string, the operator floated-in 2000 ft of casing. A tension design factor of 1.98 was realized by considering the buoyant effect of 13⅜ in. casing in 11.5 lb per gal mud. This design factor was based on 950,000 lb minimum ultimate joint strength.



— Photo courtesy of A. O. Smith Corporation

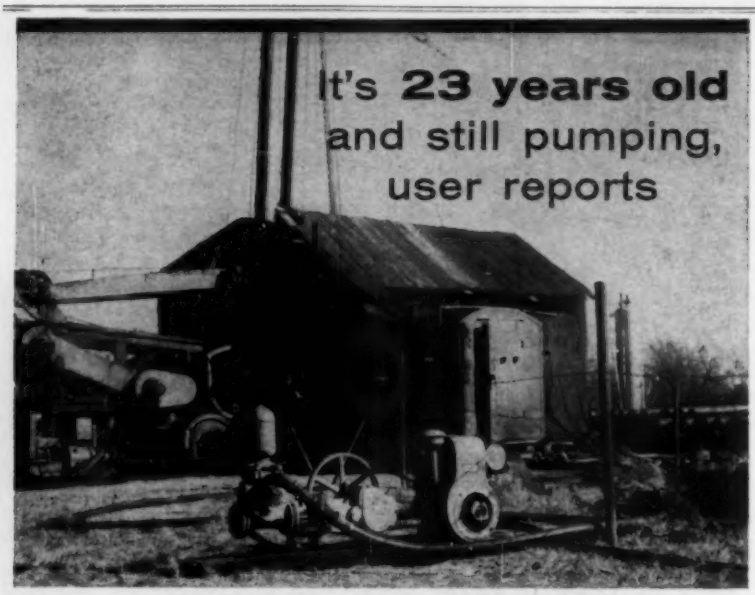
Operation was exceptional in several respects. Rig and drilling equipment furnished by the contractor, Gordon Drilling Company, probably set a record in drilling a 10,500 ft, 18½ in. hole. Casing crew ran 13⅜ in. casing in 11½ hours, and 12,000 sacks of cement were placed in 1 hour and 20 minutes.

Advance planning and drilling techniques employed by Union Oil & Gas contributed substantially to the success.

Four Union Oil and Gas men directing the operation were M. L. Euwer, vice president; D. W. McDonald, drilling superintendent; J. E. Trahan, assistant drilling superintendent; and John Gerdsen, senior drilling engineer.

Marine Drilling Platform Built in England for Shell

Marine drilling platform Triton, built for Shell Oil Company by Clelands Shipbuilding Company in England, was towed from Wallsend-on-Tyne to Cardiff, recently. The unit is berthed at Roath Docks, where it will be protected against the weather until preparations have been made for reception at a selected drilling location overseas.



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What's more, as compared to water-cooled engines, you get the same rugged power *but with up to 26 fewer parts and ⅓ less weight.* And you never have to condition an air-cooled Wisconsin for summer or winter use. You just start it and let it run — whether it's 20° below or 140° F. above zero.

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Mud Percussion Drill Field Trials Completed

First field trials of the mud-driven percussion drill, which has been under development for the past 2½ years by Continental-Emsco Company, have been completed. Company officials described results of the tests as inconclusive.

Trials were run after months of intensive engineering and laboratory-testing work, though actual on-bottom time was only 24 hours. Test was conducted on a wildcat well in Oklahoma. Field tests will resume after modification at the company's Garland, Texas, factory.

Prime purpose of the mud hammer is to lengthen the time a rock bit can economically spend on bottom, William T. Powell, executive vice president in charge of engineering and manufacturing stated recently. If the forthcoming tests are successful, he said, it may be possible to market a production model before the end of the year.

If the tool succeeds in lengthening bottom-time, drilling costs would be cut by reducing the number of round trips required.

An unexpected effect that contributes to expected lengthening of economical bit life, Powell said, is that the percussor results in a sharpening action on bit teeth that keeps them drilling cleanly long after ordinary bits have dulled.

The mud hammer also seems likely to speed drilling rates significantly, he said.

More mechanical problems have been encountered with the mud hammer than with air or gas hammer, however. In addition, it remains to be proved whether the tool will be more economical than conventional rotary drilling, since tool rental and extra cost of pump maintenance, resulting from higher pump pressures, must be balanced against extra bit footage, increased drilling rate, straighter hole, and fewer drill collars.

Drilling Substructure Rebuilt After Damage

Portable engine and derrick substructures belonging to Salt Dome Production Company have been completely rebuilt after suffering severe damage in a blowout last year, and complete changes have been made in the drilling equipment.

The mass of twisted metal and fire-gutted machinery remaining after the blowout last August was nearly beyond hope of salvage. Heavy beams and plates were buckled and warped from the intense heat, piping and electrical wiring sagged loose, and machinery suffered tremendous damage.

Entire structure has been up-dated and returned to operation.

Blowout Well Cemented, Sidetrack Completion Success

Trice Production Company has cemented its blowout well, the Trice No. 1 Nunez in the Theall field, Vermilion Parish, Louisiana, and completed the sidetrack well, Nunez No. 1-A as a commercial producer.

No. 1 Nunez encountered a totally unexpected high-pressure gas sand and blew out October 29 of last year, catching fire. This was put out and the gas was fed through two 4-in. flow lines to nearby swamps, where it was flared.

Well made a large volume of sand and shale, necessitating continual alternating between the relief lines.

Abrasive gas flow proved too much for the metal, and the well again flowed gas into the atmosphere.

Trice spudded in a relief well, the No. 1 Nunez, on November 29, 846 ft east of the No. 1 Nunez and drilled directionally toward the lowest of three productive sands encountered in the initial hole. Mud was pumped through the No. 1-A Nunez to kill the gas flow.

Just before the directional well reached the No. 1 Nunez, the blowout bridged over and Trice was able to pour mud and cement into the hole and permanently kill it.

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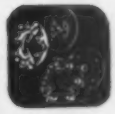
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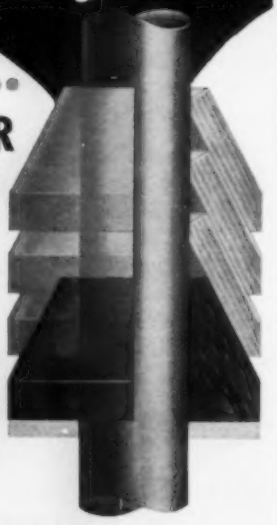

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Penrod Sets Record for Deepest Ultra-Slim Hole

Not far from the Mexican border near Laredo, Texas, Penrod Drilling Company of Dallas, Texas, is setting something of a record for ultra deep and ultra-slim holes. On a Hunt Oil Company well, Penrod last reported drilling ahead below 20,400 ft where bottom-hole temperatures were measured at 420 F. The almost unbelievable part of the well is the remarkably small size of the hole. With a 3¾-in. diamond bit, Penrod is making from 85 to 110 ft per day! Drill stem is tapered, with 2⅜ in. on bottom with specially-made drill collars just above specially-designed bit.

Drilling Bonds Raised From $5000 to $10,000

Oil and gas lease operator's drilling bonds on federal land leases have been raised from $5000 to $10,000 for increased protection of surface owners of land leases, the Department of the Interior announced.

"The proposed $10,000 bond rate is reasonable in view of rising monetary values of land improvements," Edward Woozley, director of the Bureau of Land Management, stated.

Slim Hole Drilling Credited With Savings

Slim-hole drilling and completion techniques were credited with substantial savings in Stekoll Petroleum Corporation's operations in the Texas and Oklahoma Panhandles, Canada, and North Dakota.

During the last six months of 1959, Stekoll gross oil production reached an average of 6000 bbl per day as compared with 3000 bbl daily in 1958 — an increase of 100 percent. Gross natural gas production now averages 50,000,000 cu ft per day.

Stekoll drilled 57 wells in the Anadarko Basin of the Texas and Oklahoma Panhandles during this same period. Using slim-hole drilling techniques, wells were completed for almost one-third less cost than similar wells in the area, the company reported.

Of these wells, 52 are successfully producing either oil or gas, or are in the final stages of completion, and only five were dry or uneconomic producers.

At least one-third of these wells will be brought in as dual producers, company officials anticipate. Gross holdings in this area now total 60,000 acres, and Stekoll operates these properties as the general partner in two limited partnerships and has a half-interest in net profits after payout.

On Stekoll properties in Canada, 85 percent of the 137 wells drilled were successful producers. Twelve will be dual completions.

RUNNING TOUR with MEN in the INDUSTRY

▸ **James McMahon** has joined Northern Natural Gas Company in Omaha, Nebraska, as senior reserves engineer. McMahon, previously with Shell Oil Company, will handle work involving gas reserves and availability.

James McMahon

A. F. Woodward

▸ Union Oil Company has announced the appointment of **A. F. Woodward** as manager of field and exploration operations, Pacific Coast division. At the same time it was announced that **D. F. Bowden,** chief petroleum engineer, Pacific Coast division, will be assistant to the vice-president in charge of production.

▸ **Roy M. Mays** has been promoted to director of reserves and production acquisitions for Continental Oil Company, with headquarters in Houston, Texas. He was formerly assistant general manager of Conoco's southwestern region.

▸ Personnel promotions have been announced by Southwest Gas Producing Company, Inc. **Robert L. Wood,** former chief clerk, accounting department, was elected assistant secretary-treasurer. **Fred K. Golson Jr.** succeeds Wood as chief clerk.

Al E. Beasley, district exploration manager, Lafayette, Louisiana, was promoted to general exploration manager in Monroe and will be in charge of all exploration activities.

Fred H. Plitt was promoted to senior petroleum engineer, continuing in the production department, which is in charge of **R. F. Cox,** general production superintendent.

▸ **Raymond A. Reinke** has been promoted to vice president in charge of Continental Carbon Company's international division. He will continue in charge of commercial development, with the additional responsibility of international operations. Headquarters are in Amarillo, Texas.

▸ **Frank Perkins Jr.,** former district manager for Schlumberger Well Surveying Corp. in Lubbock, Texas, has resigned to engage in independent petroleum consulting work. He is locating in Lake Charles, Louisiana.

▸ **Eugene E. Kincaid,** petroleum engineer, has joined the firm of T. W. McGuire and Associates, engineering and geological consultants, located in suite 1103, Petroleum Tower, Shreveport, Louisiana.

▸ More than 100 officials of Yacimientos Petroliferos Fiscales, the Argentine national oil company, recently heard the potential of secondary recovery in their country outlined by **Norman J. Clark** of Dallas, Texas. Clark, an international independent secondary recovery authority, recently returned from Europe where he went at the invitation of the Italian and Austrian governments to consult on oil problems.

▸ **Dr. I. Harold Silberberg,** formerly with Socony Mobil Oil Company's research laboratories in Dallas, Texas, is the new assistant director of the University of Texas division of the Texas Petroleum Research Committee.

TPRC, an industry service research unit, has laboratories at the University of Texas and Texas A & M College. It was established in 1947 by joint action of the two schools and the Texas Railroad Commission.

Dr. Silberberg succeeds **Dr. George Crawford,** who resigned to do research for the Air Force.

▸ More than 94 technical papers covering a wide variety of corrosion subjects will be presented at the 16th annual Conference of National Association of Corrosion Engineers, March 14-18, Dallas. The 1960 Corrosion Show will be held concurrently.

About 135 authors and co-authors will present papers covering general industrial corrosion problems, with discussions on theoretical and laboratory investigations. In addition, about 60 technical committees will meet to exchange information and hear reports.

Three awards, recognizing excellence in corrosion achievements, will be presented. **Morris Cohen,** Canadian scientist, will receive the Willis Rodney Whitney award, and the Frank Newman Speller award will be presented to **J. C. Hudson,** British engineer.

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C 602

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▸ **James C. Gilbert** has been named manager of land and exploration for the Husky Oil Company. Gilbert has been manager of appraisals and economics. He will continue to do work in these fields in addition to carrying out his new responsibilities in land and exploration.

▸ **R. B. Bowman** has been appointed senior technical assistant in the invention development division, patent department, of California Research Corporation, San Francisco, and **W. J. Rossi** was appointed to the position of senior engineer in the same department. Bowman was formerly research coordinator in oil field research; Rossi was group supervisor in process and plant design at the Richmond laboratory.

The appointment of **R. E. Doe** to the position of geophysics associate-applied geophysics, La Habra laboratory, has also been announced. He will be responsible for new methods development and application in the geophysics development division. **Richard C. Goodknight** has joined the producing technology division at the same laboratory.

▸ As a result of expanding foreign operations, Kerr-McGee Oil Industries, Inc., has appointed five members of its production and drilling operations division to new posts. Now serving in their new positions are: **Charles F. Miller,** manager of foreign production and drilling operations; **Kenneth W. Parker,** project superintendent, Bolivian operations; **Burrell G. Taylor,** manager of production department; and **Harry C. Hanna,** general superintendent of production department. **John I. Fisher** continues as superintendent of gas contracts, with the additional responsibility of supervising the production department engineering section.

▸ Two retirements and six promotions in Sun Oil Company's Southwest production land department have been announced. **S. B. Christy Jr.,** district landman at Roswell, New Mexico, and **C. C. Pope,** assistant district landman in charge of the company's San Angelo, Texas, office, are retiring. **John P. Carnes,** district landman at Shreveport, Louisiana, succeeds Christy. Senior landman **Paxton Robertson** of Lubbock, Texas, was moved to Shreveport, succeeding Carnes.

W. O. (Bill) DeWitt, scout at Midland, Texas, was named junior landman and will continue officing in Midland. Roswell scout **Frank Haughton** was promoted to junior landman and will move to the Abilene, Texas, office. **George McFall,** draftsman in the Dallas office scouting department, has transferred to Roswell as junior scout. **Jack Everett,** formerly in the title record department, Dallas, has moved to Midland as junior scout. Land department offices will no longer be maintained at San Angelo and Lubbock.

▸ A memorial portrait of **Frederick Byron Plummer,** founder and first chairman of the University of Texas petroleum engineering department, was unveiled February 9 at ceremonies dedicating a new 1500 sq ft study room for petroleum engineering students. Prof. Plummer's former students, friends, and colleagues contributed for the portrait, dedicatory plaque, and establishment of a Plummer Recognition Scholarship trust fund. Prof. Plummer, pioneer petroleum engineering researcher, died in 1947. The American Association of Petroleum Geologists cited Plummer as one of the "top half-dozen men to whom we are indebted for our present comprehensive knowledge of Texas geology."

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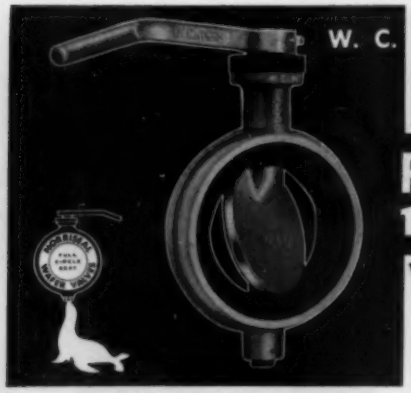

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VALVES

A. M. Wiederkehr

E. L. DeMaris

▸ **A. M. Wiederkehr** was elected vice-president, exploration, at a recent meeting of the board of directors of Southern Union Gas Company, Dallas, Texas. In his new position, Wiederkehr will be in charge of the company's land, geological, drilling and production departments.

▸ After more than 36 years with General Petroleum Corporation, **Elmer L. DeMaris,** 1404 Wembly Road, San Marino, California, is retiring. Prior to the merger of General Petroleum and Mobil Oil Company on January 1, 1960, DeMaris was manager of petroleum engineering, production department. He plans to engage in independent consulting work including oil and gas property appraisals.

Frank B. Carter, formerly senior administrative geologist in the exploration department, has also retired. He plans to be a consultant in geology and petroleum engineering.

▸ **A. Lee Jones,** regional geologist for Plymouth Oil Company, Sinton, Texas, retired March 1. **John R. Puryear,** geologist at Sinton, was advanced to fill the vacancy.

▸ **Dr. Earl Ingerson,** University of Texas geology professor, has been elected the new secretary of the commission on geo-chemistry of the International Union of Pure and Applied Chemistry, for a three-year term. As secretary, Dr. Ingerson's first job is to help plan a symposium on the geochemistry of sedimentary carbonate rocks to be held in conjunction with the International Geological Congress next August in Copenhagen. Other officers are **Prof. Carl W. Correns** of the University of Goettingen, Germany, president, and **Prof. A. P. Vinogradov** of the Russian Academy of Sciences in Moscow, vice-president.

▸ **Captain Albert S. Miller,** director of naval petroleum and oil shale reserves, Department of the Navy, Washington, D. C., was guest speaker at the recent regular monthly dinner meeting of the Desk and Derrick Club of Los Angeles, California.

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▸ Various promotions in the domestic producing department of Texaco Inc. have recently been effected. **Robert H. Park** was promoted to assistant division manager, gas division, and **Erwin A. Gromatsky** was advanced to chief gas engineer, general manager's office. Both Park and Gromatsky will be located in Houston. **V. C. Scott** was promoted to chief geologist. On March 1 **R. E. Griswold,** who was staff geologist in the New York offices, became assistant to the Dallas, Texas, division manager.

▸ **W. J. Garrison,** scout for Humble Oil and Refining Company, Houston, Texas, has been named president of the International Oil Scouts Association. **William P. Allen,** chief scout, Imperial Oil Ltd. in Calgary, was formerly president and was the first Canadian president of the 36-year old association, whose principal work is the publication of a Year Book on oil activity for the petroleum industry. The material is gathered by 34 district scouting associations scattered over the U. S. and Canada.

▸ Honorary membership, the highest distinction in the American Institute of Mining, Metallurgical, and Petroleum Engineers, has been awarded to two men of outstanding achievement in the oil industry.

The honor was bestowed February 17 during AIME's annual banquet in New York. Awards were made to **John M. Lovejoy,** of New York, consultant on oil investments and **William E. Wrather,** Washington, D. C., former director of the United States Geological Survey.

MERLA'S NEW

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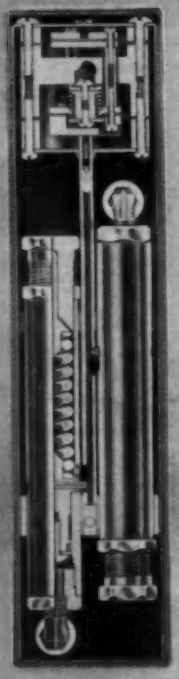

This versatile control is primarily used as a safety control high-low shut-off. The E-1 is also used in well purger, back pressure and pressure reducer service. The Type E-1 offers:

- Two pressure sensing elements to take pressure from two separate points
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▸ **C. Hayden Atchison** has been promoted to the position of exploration coordinator for British-American Oil Producing Company's headquarters offices in Dallas, Texas. He was formerly division manager of exploration for the company in Midland, Texas.

In his new post, Atchison assumes the responsibilities of the former chief exploration geologist, **R. C. Marmaduke,** whose resignation became effective January 4. In addition, Atchison will be responsible for coordinating the company's exploration program throughout the United States.

Jack L. Hollis has been designated exploration administrator of B-A with headquarters in Dallas. In this capacity he will retain his former position as chief geophysicist and will also serve as exploration department personnel supervisor and business manager.

▸ The Pure Oil Company is taking steps to reorganize the field operations of its exploration and production division.

About July 1, its Rocky Mountain producing division with headquarters in Denver, its Southwestern division in Tulsa, and its Eastern division in Olney, Illinois, will be consolidated to form the Northern producing division with headquarters in Denver. About September 1, its Texas producing division in Fort Worth and Gulf Coast division in Houston, will be consolidated to form the Southern producing division with headquarters in Houston.

As a result of the action, Pure will materially enlarge its Denver and Houston staffs and close its offices in Tulsa and Fort Worth. A producing office will be maintained in Olney.

Charles W. Hancock will become manager of the new Northern producing division, and **James L. Morris** will head the Southern producing division.

William M. Peck, manager of the Southwestern division, and **Worth M. Saxon,** Eastern division manager, have elected to take early retirement at the time of the consolidation. **Chase Sutton,** Gulf Coast division manager, will become senior manager of the Southern division.

▸ **Dr. C. G. Williams,** director and general manager of Shell Research, Ltd. in London, England, has been nominated by the council of the Institution of Mechanical Engineers as a member of the board of studies in engineering of the National Council for Technological Awards.

National Council is concerned with the recognition of Colleges of Advanced Technology and the award of the Diploma in Technology.

▸ **Joe Mefford,** assistant division production superintendent with the Tulsa division of Sinclair Oil & Gas Company, has been promoted to division production superintendent with the Midland, Texas, division.

He succeeds **O. G. Simpson,** who was named division manager at Midland.

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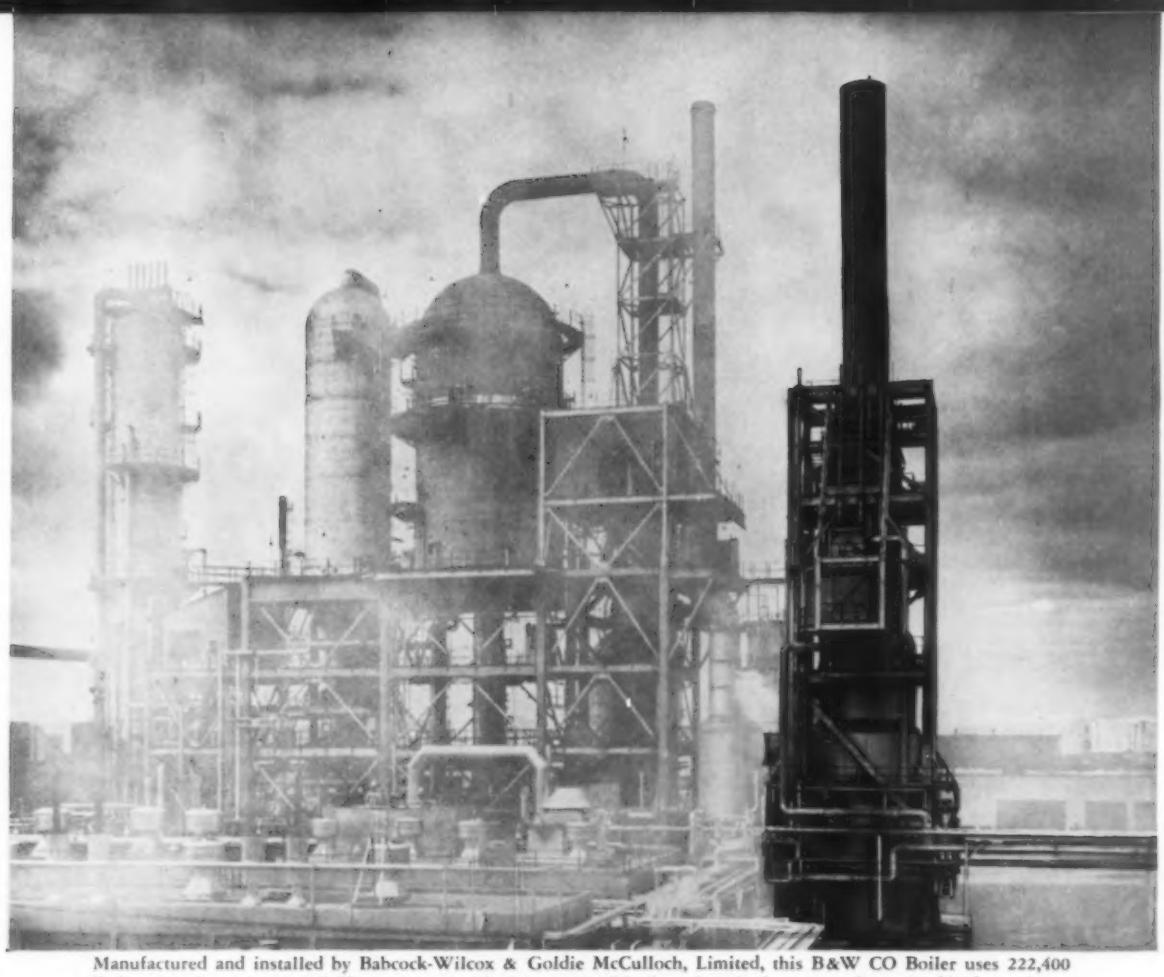

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At the Montreal East Refinery of the British American Oil Company, a B&W CO Boiler installed in October, 1957, has proved to be a sound investment. Waste CO gases, normally released to the atmosphere, are put to work to generate 60,000 pounds of steam per hour. Add to this the 90,000 lb per hour generated by the unit from conventional fuels and you have a total output of 150,000 lb per hour. No wonder British American points to this unit with pride. It saves them thousands of dollars yearly in fuel costs; furnishes a dependable supply of high quality steam that helps over-all refinery efficiency.

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Find out how a B&W CO Boiler can Help you Cut Costs. These are practical advantages that can help improve your refinery operations. There are many more that add up to increased efficiency and economy. Get the complete story by writing for Bulletin G-87, The Babcock & Wilcox Company, Barberton, Ohio.

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CONSTRUCTION BRIEFS . . . news of plants to come

Styrene capacity to triple at Cosden Petroleum Corporation's Big Spring, Texas, multi-million-dollar plant expansion now underway and scheduled for completion late this year. Styrene capacity to be 60 million lb annually through addition of facilities for styrene monomer and this country's first Alkar unit.

Vinyl chloride monomer plant slated for Houston by Ethyl Corporation and scheduled for completion early in 1961. New plant to supplement Ethyl's vinyl chloride monomer plant at Baton Rouge, Louisiana.

Udex-benzene unit for DX Sunray Oil Company at Tulsa, Oklahoma, recently announced, will produce 600 bbl of benzene and 300 bbl of toluene daily. Currently under construction is a $7 million solvent de-waxing unit to nearly double current wax production.

800 million lb annually: ultimate capacity of Dow Chemical Company's styrene monomer plants located at Freeport, Texas, and Midland, Michigan. Expansion of styrene monomer production involves both plants and is slated for completion by late 1960 or early 1961.

New petrochemical contender will be Bay Petroleum Company, a division of Tennessee Gas Transmission Company, of Houston, with the construction of a 2000-bbl daily aromatics unit at its Chalmette, Louisiana, refinery. Products include benzene, toluene, xylenes and heavier aromatics. Construction to start about mid-year and completion expected in spring of 1961.

New phenol plant will be built by Dow Chemical Company in Kalama, Washington. Construction now underway for completion by mid-1961. Plant capacity will be about 36 million lb per year.

New company, new plant for production of dodecylbenzene, was announced with the formation of Witfield Chemical Corporation, a joint venture by Richfield Oil Corporation and Witco Chemical Company, Inc. of New York. $1.75-million plant to be located adjacent to Richfield's Watson refinery in Los Angeles and completion is scheduled early next year.

200,000-bbl underground propane storage cavern in Ponca City, Oklahoma, for Continental Oil Company to cost $1.275 million. Mining operations now underway in a limestone 350 ft underground with completion set for early 1961.

$10 million styrene monomer plant to produce 70 million lb annually will be built near Houston, Texas, by Sinclair Oil Corporation and Koppers Company, Inc. of Pittsburgh. Construction just underway with operations to start by mid-1961. Ethylbenzene to be separated from an aromatic stream produced at Sinclair's Houston refinery, and then converted to styrene monomer by dehydrogenation.

580 million lb ethylene annually is 1961 goal of Phillips Chemical Company for its Sweeny, Texas, plant where new construction will raise output to 290 million lb by second quarter this year. When completed late in 1961, capacity will nearly double this figure.

$30 million plant expansion program announced by Dow Chemical Company for its Louisiana Division at Plaquemine, Louisiana, covering construction for the next two years. Current expansion is a $12-million project for operation this fall. Construction will include a new ammonia plant, increases in chlorine, caustic soda and vinyl chloride capacity. When completed, the new expansion program will bring Dow's total investment at Plaquemine to more than $100 million.

International Briefs

Central America's first refinery will be $30-million plant located on Payardi Island near Colon, Panama. Refineria Panama, SA, jointly owned by a subsidiary of Continental Oil Company and National Bulk Carriers, Inc., will employ some 200 persons when plant is completed early 1962.

$49 million Australia expansion by Shell at its Clyde, New South Wales refinery to begin this year and cover three-year program. Construction to include a new $38-million catalytic cracking plant, a new $22.5 million ethylene unit, new port facilities and pipeline.

Procon (GB) to build Mozambique's first refinery. A contract was recently let by Sociedade Nacionale Refinacao de Petroleos, a Portuguese company. To be completed early in 1961, the new plant will include a 12,000-bbl crude unit; a 2500-bbl Platforming unit; a 2000-bbl diesel fuel Unifining unit, and and a 1500-bbl Merox unit, (capacities in barrels per stream day).

Canada's largest gas plant, to be located near Rimbey, Alberta, will process up to 326 million cu ft of gas daily and will cost an estimated $12.5 million. British American Oil Company will serve as plant operator for a group of 25 owner-companies. Completion will be late in November 1960.

Texaco's Trinidad expansion of its Pointe-a-Pierre refinery will cost $18 million and will increase daily capacity from 135,000 to 255,000 bbl.

Royal Dutch/Shell in Argentina will expand its Dock Sud, Buenos Aires refinery at a cost of $21.8 million.

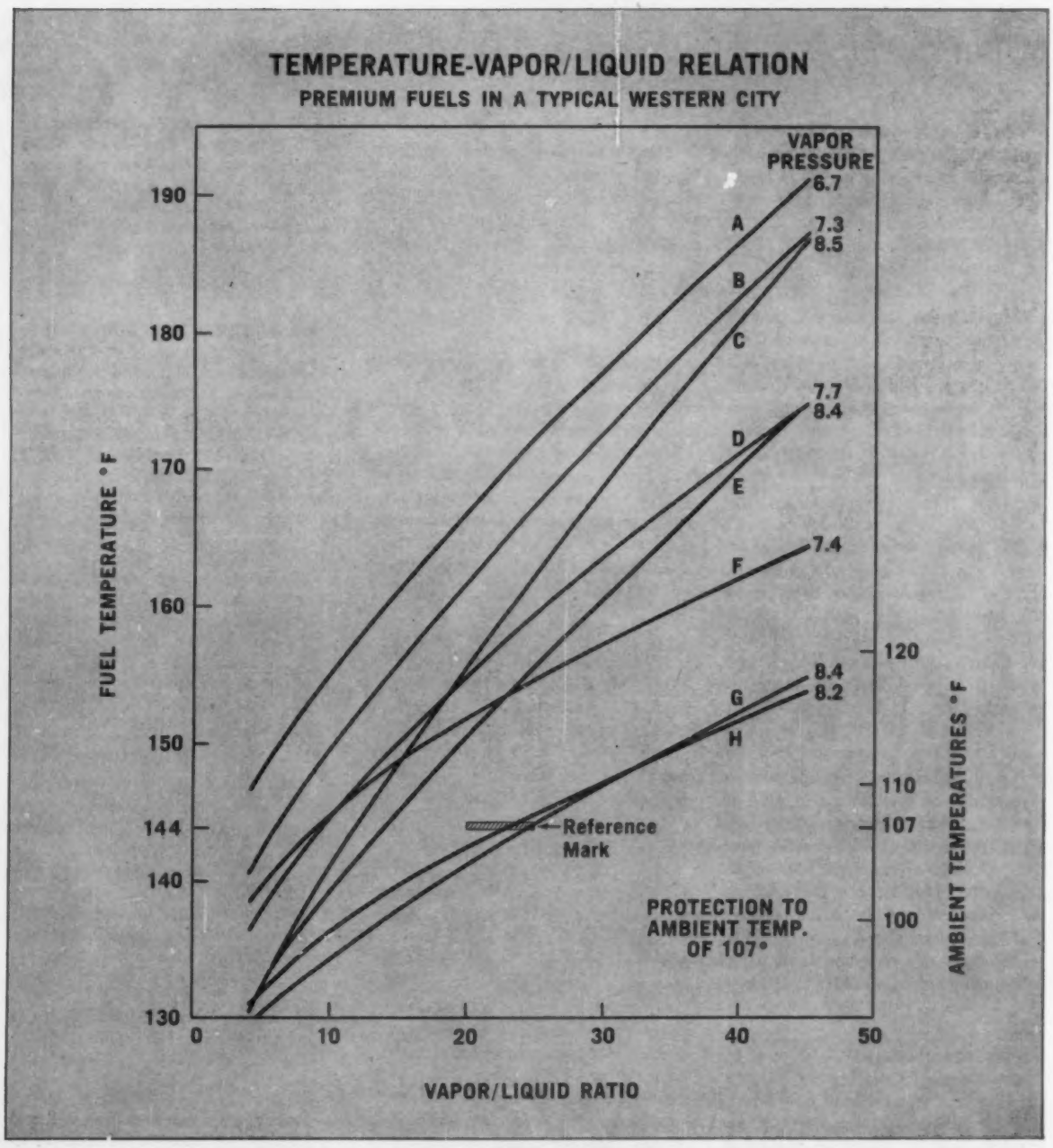
In Union of South Africa, Shell Oil Company plans a $70-million refinery at Durban.

The Oil Consortium in Iran will add a $9.6-million catalytic reformer to its Abadan refinery.

Here's a practical method for analyzing Front-End Volatility

Ethyl Research uses temperature-vapor liquid ratio curves to study relative and absolute front-end characteristics of gasoline

by **GILBERT WAY**—*Research Representative*



The above curves were calculated by the CRC method using Ethyl Volatility Survey data.

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WHERE TO SET front-end volatility for optimum balance of economic and automotive benefits is an important question for refiners.

One result of Ethyl's work in this field is a routine approach to interpretation and comparison of seasonal volatility data. The method can be used to establish or review volatility requirements at both the refinery and marketing levels. Data from the Ethyl Volatility Survey are used as the basis for temperature-V/L studies. *Refiners may have analyses of their own marketing areas upon request!*

Method is Simple; Easy to Understand

Temperature-V/L ratio curves—widely accepted as a graphic representation of how gasoline vaporizes in a fuel system—are used to show the volumes of vapor formed per volume of liquid at any given gasoline temperature. (Curves were calculated by the CRC method.)

In addition to showing relative vaporizing tendencies among various fuels, the curves may be related to reference points that indicate average conditions of fuel temperature and limiting V/L in automotive fuel systems. In the accompanying graph, average conditions for premium fuels are shown by the reference mark ranging from 20 to 25 V/L at a fuel temperature of 144°F.

This reference mark range was established from the results of extensive road tests conducted in recent years. Many factors were considered in arriving at this practical bench mark, such as severity of test conditions, age and condition of fuel system components, and variation of individual cars from average characteristics.

In theory, a fuel having a curve which passes through the reference mark would represent highest desirable use of front-end "fill." Those above the mark would be more conservative and those below subject to vapor lock.

The estimate of fuel temperature was established by adding the temperature rise at the fuel pump under severe vapor locking conditions and the ambient temperature to which protection against vapor lock is desired. Experience has shown that this fuel temperature rise at the pump averages 37°F. In the marketing area represented in the graph, protection is desired up to 107°F.

Some Interesting Observations on Volatility

The figure shows a wide variation in vaporizing tendency of fuels. Fuels A, B and C indicate a conservative position. This is contrasted by high volatility and border line protection against vapor lock by curves of fuels G and H.

Curves having steep slopes are typical of fuels pressurized by butane. Those with flat slopes indicate a high pentane content. Fuels C, E and G have essentially the same Rvp of 8.4 to 8.5. They converge at a V/L of 4, the V/L of the Reid vapor pressure bomb.

A V/L of 25, however, is reached by fuel G at a fuel temperature of 144°F., whereas fuel C must reach 163°F. before evolving the same quantity of vapor. Thus fuel C offers more protection against vapor lock than fuel G when abnormally high temperatures are encountered. This illustrates that, *for a given Rvp, butanized* fuels offer greater vapor lock protection in motor vehicles than fuels that are pressurized largely by pentane. Another way of comparing these two fuels is at constant temperature: at 150°F., fuel G has 35 V/L, fuel C only 16.

How Ethyl Research can help you

In addition to participating in Oil Industry cooperative studies, Ethyl Research has worked with many individual oil companies in studies of vapor locking tendencies of fuels and engines.

The experience gained in these programs provides a broad understanding of the problems associated with front-end volatility.

Our engineers are prepared to bring you analyses of Temperature-V/L characteristics of fuels from marketing areas of your choice.

If you would like this service, or more information about it, just call your Ethyl Representative. He'll be glad to make the arrangements.

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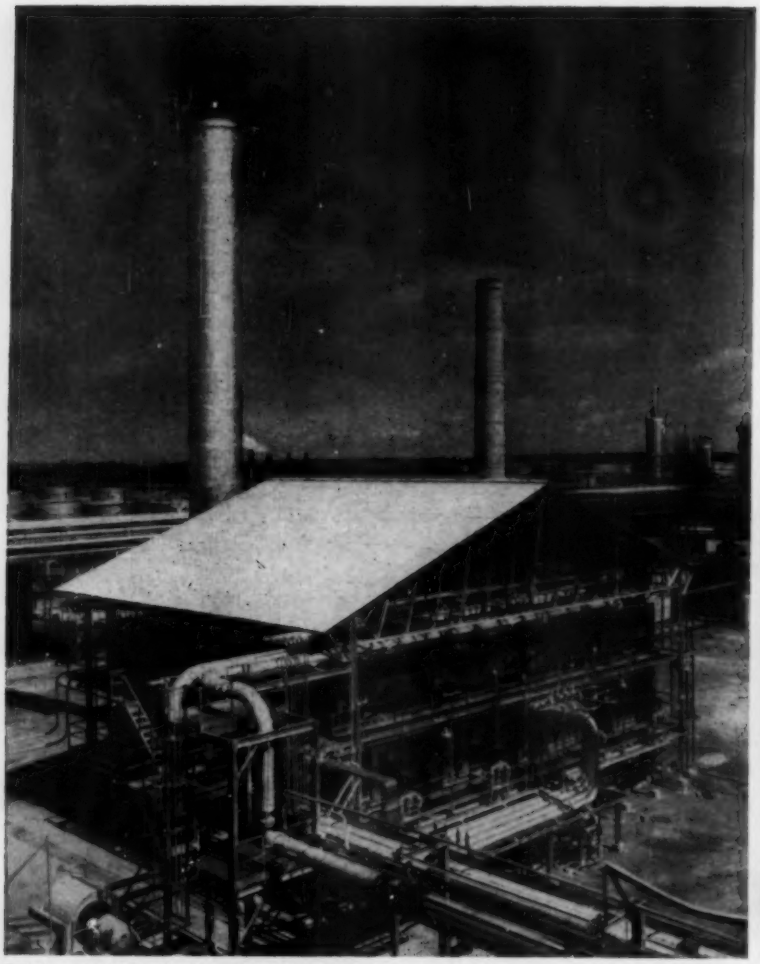

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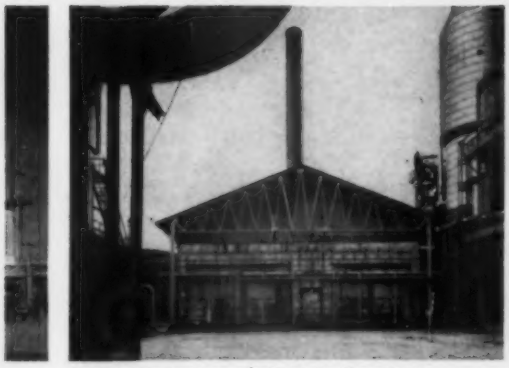
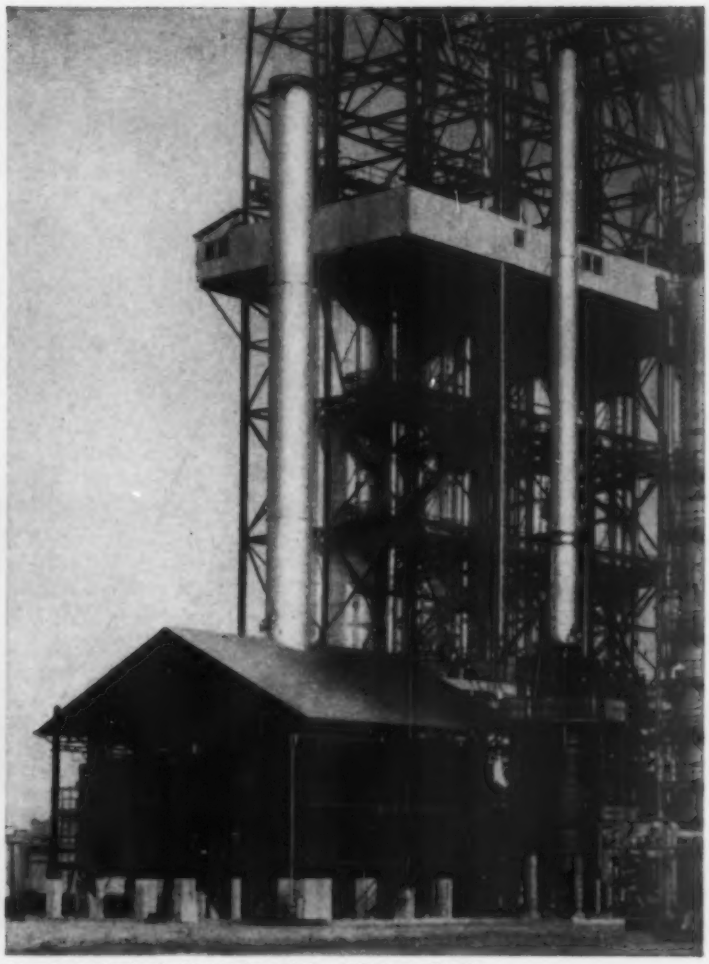


Crude heater for Socony Mobil at Paulsboro, N. J.



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Special Issue Editor

Dr. Robert N. Maddox, P.E.

Refining Engineer is honored to have Dr. Robert N. Maddox, professor and head of the School of Chemical Engineering, Oklahoma State University, as special editor of this issue devoted to gasoline plant design. Dr. Maddox is familiar to *Refining Engineer's* readers for his technical papers "The Digital Computer as an Aid in the Design of Distillation Columns," April 1958; "Petroleum in 2059," August 1959, and (with J. H. Erbar) "Programming Plate to Plate Distillation Calculations," September 1959. For his able assistance in planning contents, securing articles, and giving technical assistance on the presentation of this entire issue, *Refining Engineer* wishes to extend to Dr. Maddox very sincere thanks.

▸ What holds a top flight young engineer in the teaching field despite the temptation of lucrative offers from industry?

Refining Engineer's April special issue editor, Robert N. Maddox, at 34 the professor and head of the School of Chemical Engineering at Oklahoma State University, Stillwater, explains it this way:

"Some people, of course, find greater personal challenge and opportunity in industry. But since I was a child, I've wanted to be a university professor. I can't really say why, because I grew up in a town of about 300 people (Winslow, Arkansas) and didn't know anybody on a university faculty. But for some reason this just appealed to me, and I've never seen any other job that had more, if as much, appeal to me. I enjoy the classroom work. I like having the students work with me on research projects. And I have a feeling of accomplishment . . . that I had a small part in it . . . when somebody like John Erbar finishes up and goes out to make his own name as an engineer."

(Erbar, recently awarded a PhD in chemical engineering at Oklahoma State, is now a research engineer at California Research Corporation's Richmond laboratory.)

Maddox, only 32 when elevated to his present post, was probably the youngest man in the nation to hold such a position at the time, at least in a large accredited school. Oklahoma State is considered by many to have the best graduate school of chemical engineering between the Mississippi and the West Coast.

His own educational background consists of a BS in chemical engineering from the University of Arkansas (1948), MS from the University of Oklahoma (1950), and PhD from Oklahoma State (1955). His dissertation subject: "Performance Characteristics of the Valve Type Perforated Tray."

Maddox has been on the Oklahoma State faculty since 1950, except for a period from May 1951 to September 1952 when he was a design engineer in the process division of Black, Sivalls & Bryson, Inc., Oklahoma City. There he was responsible for the design, construction, and start up of natural gasoline plants. His work also involved troubleshooting on existing plants that encountered difficulty and testing of new products in plant size equipment, including analysis of these tests to determine suitability of the equipment for natural gas processing use.

He has accomplished important research in distillation and absorption using a medium sized computer and is currently writing a book along with Wayne Edmister, PE, also of the Oklahoma State faculty.

His professional affiliations include the American Institute of Chemical Engineers (chairman, central Oklahoma section); Sigma Xi; Registered Professional Engineer (Oklahoma); National Society of Professional Engineers; American Society for Engineering Education; Who's Who in Engineering, Tau Beta Pi, and Sigma Tau.

Maddox is married to the former Miss Paula Robinson of Okemah, Oklahoma, who holds a BS in wildlife conservation from Oklahoma State, and who shares his enthusiam for fly fishing for bass. (Maddox ties his own flies.) They are parents of a daughter, Deirdre O'Neil, 4, and a son, Robert Dozier, 11 months.

Can you use 10% more lean oil circulating capacity?

A Simple Sponge Oil Unit May Do the Trick

ACCORDING TO WEBSTER, a sponge is an absorbent usually used in cleaning. In a sponge oil unit, a high molecular weight sponge oil absorbent is used to clean absorber residue gas of its absorption oil content. The magnitude of the cleaning job depends upon lean oil molecular weight and absorber operating conditions.

For good absorber design and operation, the amount of oil vapor in the residue gas depends upon an economic balance. The earnings from incremental products attributable to lower lean oil molecular weight must offset the cost of the lost oil. With a sponge oil unit to recover lean oil vapors from the residue gas, lean oil molecular weight can be reduced 10 percent for most systems which increases lean oil circulating capacity a similar amount on a molar basis.

Sponge units fit into plant operating pictures as follows:

Case 1. An existing plant can recover more products but cannot justify a large expansion program. A 10 percent increase in oil circulating capacity at nominal investment may fit.

Case 2. Product recovery is high during winter months but summer temperatures cause recoveries to fall. Decreased operating expenses during the winter coupled with increased earnings during the summer may justify a sponge oil unit.

Case 3. Product recovery is good but the lean oil circuit is overloaded causing frequent operational upsets. A sponge oil unit will reduce lean oil rates for a given product recovery, reducing equipment loading and operating expenses.

Case 4. It is desirable to reduce the oil vapor content of the residue gas for any reason. High molecular weight sponge oil can reduce the oil vapor content of residue gas to insignificance.

Process Description

For any given unit, the sponge oil characteristics can vary widely depending upon:

(1) The design sponge oil vapor loss,
(2) The operating conditions of the absorber,
(3) The characteristics of available oils, and
(4) The ability to separate the recovered components at reasonable operating conditions.

High molecular weight material will substantially cut absorption oil consumption, but larger equipment is required.

For most plants, the capabilities of the still will establish the lower limit of the system oil molecular weight. The ability to separate the raw products from the lighter oil is particularly important. Here the number of trays, overhead condensing capacity, reflux pumping capacity, and desired saturation may cause excessive light oil losses to the raw product.

In 1958, a sponge oil unit was added to the Wichita, Kansas, gasoline plant of Cities Service Oil Company. The system oil molecular weight has been gradually reduced from 195 to 168. Operating experience for this unit has been very satisfactory.

Fig. 1 shows a simplified flow diagram of the Wichita plant. The normal absorber — rich oil fractionator — still system is followed by lean oil dehydration where plant fuel is used for stripping water from the lean oil. The sponge oil unit is connected to the plant process at only two points. Absorber residue gas is routed through the sponge oil absorber, and fuel gas to the lean oil dehydrator is routed through the sponge oil stripper. Fig. 2 shows the Wichita sponge oil system flow with normal operating conditions.

The Wichita unit is not typical since fuel gas is used for stripping and system lean oil is used for stripper reflux. The stripping operation can be handled at atmospheric pressure with reflux condensing. Also sponge oil heating may be used. Fig. 3 shows a self contained unit with these features which can be adapted to skid installation. Absorber rich oil can be used for the unit cooling requirements.

Design Procedure

The design of a sponge oil system begins with the selection of the new absorption oil and the sponge oil. Many different

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Duane F. Hogsett
Project Engineer
Cities Service Oil Co. (Del.)

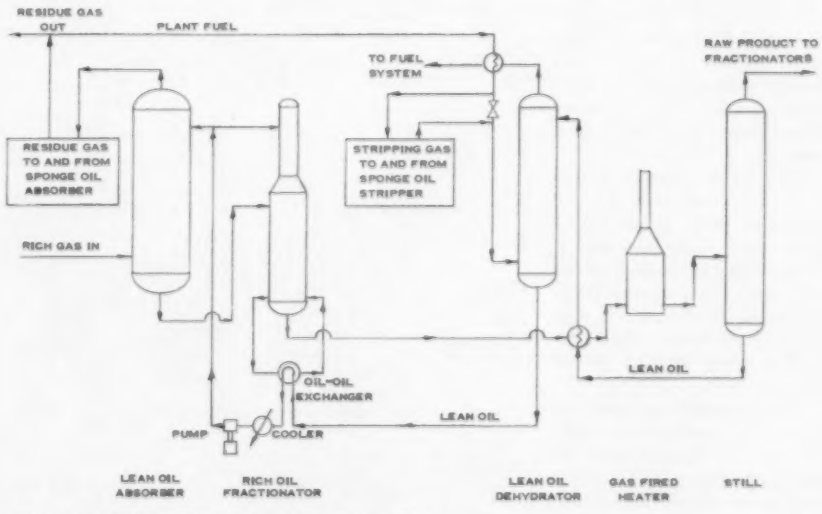

FIG. 1. Simplified flow diagram, Wichita gasoline plant.

products are available with wide variations in properties and price. Most oils that meet a molecular weight specification are blends that do not have a narrow boiling range.

The system lean oil is somewhat different from the makeup oil as purchased in all plants. The same deviation must be estimated for the new makeup oil. At Wichita, 180 molecular weight oil was purchased but system oil averaged 195 molecular weight. Now, 160 molecular weight oil is used with the sponge oil system to maintain a 168 molecular weight system oil.

A 240 molecular weight sponge oil was investigated, but a 290 molecular weight material was selected to further reduce oil consumption. Also, by using a heavier oil, the sponge oil unit design is more conservative. One 310 molecular weight material was offered that looked promising, but it turned out to be a super-refined lube oil stock at double normal absorption oil prices.

The ASTM distillation curves for the proposed oils are readily available and can be converted to true boiling point curves.[3] For narrow boiling range oils, this conversion is not essential, for the difference between the ASTM and TBP curves is within the accuracy of predicting final oil characteristics. The true boiling point curves can also be converted to molar true boiling point curves,[1] but the change from volume to molar percent distilled is usually negligible. True boiling point curves for the 290 molecular weight sponge oil, the 195 molecular weight system oil, and the 172 molecular weight projected new system oil are shown in Fig. 4. Each oil is arbitrarily divided into three or four fractions designated as C_A and C_S for absorption and sponge oil components respectively. These fractions are further numbered from light to heavy for identification and are used throughout the design calculations.

Next, equilibrium vaporization constants (K factors) must be developed over the expected operating range. The literature[4,6] provides K factors in the range of 10^{-4} to 10 for many oil fractions, but the sponge oil absorber design is based on values as low as 10^{-9}.

For this design, the NGAA K factors were plotted against component boiling point and projected to the boiling point of the various oil fractions. Values of Poettman and Mayland[4] as well as Smith and Smith[6] were used for extrapolation guides. Fig. 5 shows typical projection curves for a pressure of 300 psia.

The same procedure was used for pressures of 10, 40, and 100 psia. These values were then cross plotted to form K charts for each of the individual oil components involved in the design. Fig. 6 is the K chart for C_{S1}, the 590 F boiling point fraction of the sponge oil.

The K charts are used for evaluation work long after the unit is in operation. As the properties of the system and/or sponge oil change, the fraction size is adjusted to retain the same boiling point. If the oils change substantially, additional K charts can be developed as required.

With the oil and K factor information completed, the system design can begin. The procedure includes:

1. **Estimate sponge oil vapor loss** from the sponge oil absorber to check consumption and residue gas oil content. Also check light oil vapor loss from absorber to establish sponge oil absorption requirements.
2. **Calculate the sponge oil circulation** rate for the design system oil recovery.
3. **Establish sponge oil stripper conditions** for desired separation.
4. **Fill in pumps, exchangers, heater, controls, etc.**
5. **Estimate unit cost,** operating expenses and earnings.

At Wichita, typical summer absorber conditions are 200 psia and 100 F (top tray) with a residue gas volume of 100 MMcf per day. These conditions are used for the following calculations.

1. The quantity of oil vapor in the residue gas is calculated by dew point and bubble point relations. In Table 1, the method used in estimating the sponge oil vapor loss is demonstrated. The relative volatility of the sponge oil fractions gives the composition of the sponge oil vapor. After calculating the dew point contribution of the residue gas, the sponge oil quantity is established by difference. A design sponge oil loss of 2.2 gal per day or 0.022 gal per million cubic feet of gas is indicated.

A similar calculation shows a loss of 1080 gal per day of 172 molecular weight oil to the sponge oil absorber, or 10.8 gal per MMcf. Also, 250 gal per day of the 195 molecular weight system oil was being lost or 2.50 gal per

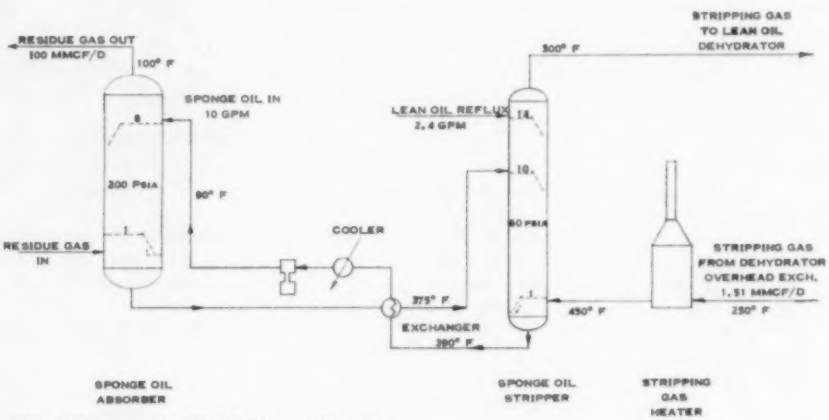

FIG. 2. "Sponge oil unit", Wichita gasoline plant.

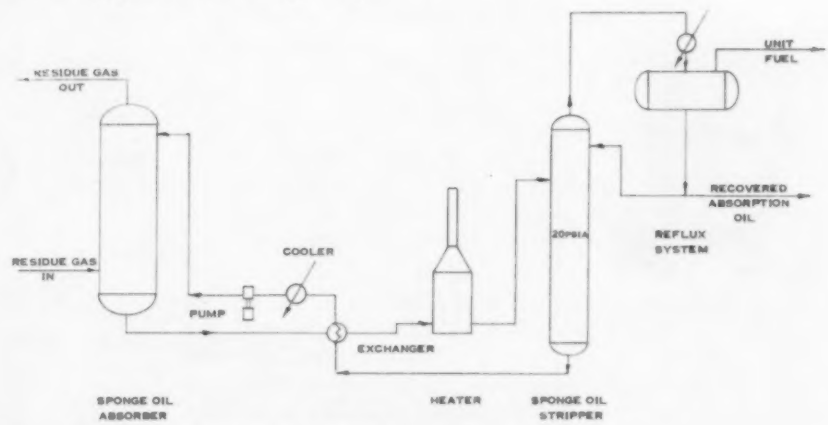

FIG. 3. Self contained "sponge oil unit" for skid installation.

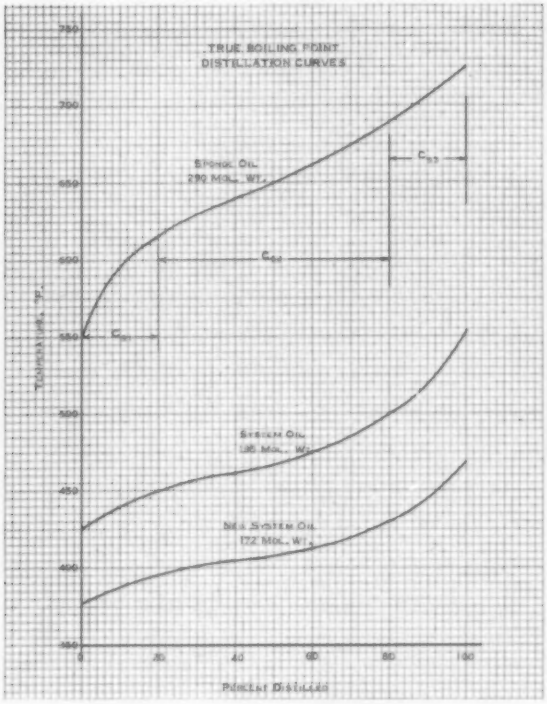

FIG. 4. True boiling point distillation curves.

MMcf. These figures indicate a four-fold increase in oil content of the residue gas by reducing the molecular weight from 195 to 172.

2. The sponge oil circulation rate is established by a normal absorption calculation. Table 2 shows the Kremser-Brown method[7] using an average oil-gas ratio. The absorption efficiency was set to recover 98 percent of the C_{A1} fraction, the 386 F boiling point material. An 8-tray absorber was installed and 2.5 theoretical trays were assumed for design.

The calculated summer sponge oil circulation rate of 9.4 gpm drops to as low as 4.5 gpm during the winter for the same absorption efficiency. In actual operation, however, the rate remains constant because of the small volume involved. A circulation rate of 10 gpm was established at Wichita with all equipment sized for 20 gpm.

It should be noted that some 15 gal per day of system oil remains in the residue gas even with the high absorption efficiency. The presence of this oil will reduce the calculated sponge oil loss of Table 1.

3. Any significant system oil saturation in the sponge oil will increase the total oil vapor losses; consequently the stripper design is critical for good unit operation. Since the lean oil dehydrator was available at Wichita, the simplified stripper was selected utilizing fuel gas for stripping.

The rich sponge oil is heated through oil exchange to 375 F and is flashed into the stripper operating at 60 psia. The stripping gas enters at 450 F which gives a 400 F average temperature through the stripping section. Table 3 gives typical flash and stripping calculations.

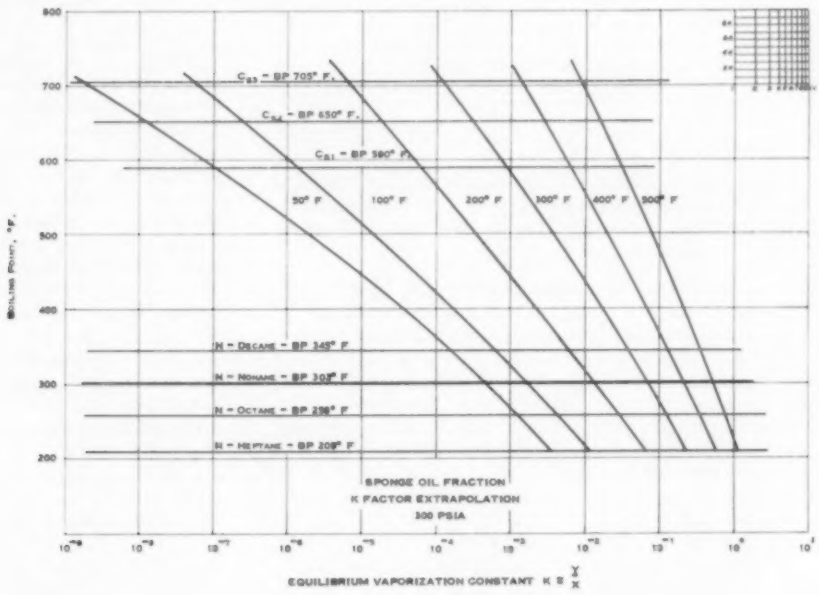
C_{B3} - BP 705° F.
C_{A4} - BP 650° F.
C_{A1} - BP 590° F.
50° F
100° F
200° F
300° F
400° F
500° F
N - Decane - BP 345° F
N - Nonane - BP 303° F
N - Octane - BP 258° F
N - Heptane - BP 209° F
Boiling Point, °F.
Sponge Oil Fraction
K Factor Extrapolation
300 PSIA
Equilibrium Vaporization Constant K = y/x

FIG. 5. Sponge oil fraction, "K" Factor extrapolation — 300 psia.

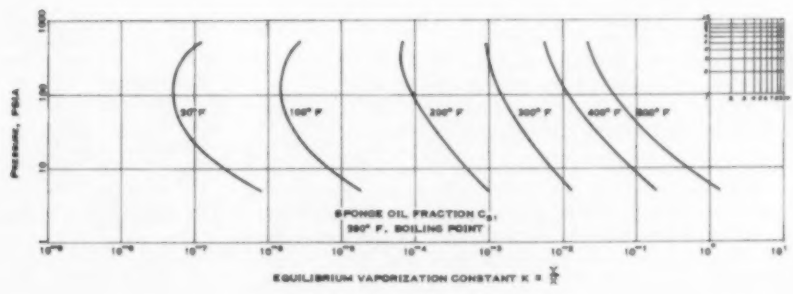

FIG. 6. Sponge oil fraction, C_{A1}, 590 F boiling point.

Table 1. Calculation Method to Determine Sponge Oil Vapor Loss to Residue Gas 200 PSIA and 100° F

COMPOSITION OF SPONGE OIL VAPOR

Component	Liquid Mol Fraction	K	K x = y	Vapor Mol Fraction
C_{S1}	.2	9×10^{-7}	1.8×10^{-7}	.703
C_{S2}	.6	1.1×10^{-7}	0.66×10^{-7}	.258
C_{S3}	.2	5×10^{-8}	0.10×10^{-7}	.039
		Average K =	2.56×10^{-7}	

DEW POINT CONTRIBUTION OF RESIDUE GAS

Nitrogen	.084	62	.001
Methane	.820	14.3	.057
Ethane	.062	3.0	.021
Propane	.027	.97	.028
Butanes	.007	.36	.019
	1.000		.126

$Ys/Ks = 1.000 - 0.126 = 0.874$

$Ys = 0.874 \times 2.56\times10^{-7} = 2.24\times10^{-7}$ Mol Fraction

SUMMARY

SPONGE OIL COMPONENT MOL FRACTIONS IN RESIDUE GAS ARE:

$C_{S1} = 1.57\times10^{-7}$
$C_{S2} = .58\times10^{-7}$
$C_{S3} = .09\times10^{-7}$

FOR 100 MMCF/DAY (263, 500 MOLES), THE SPONGE OIL LOSS IS:

$2.24\times10^{-7} \times 2.635\times10^{5} = 0.059$ MOLES/DAY

OR $0.059 \times \frac{37.7 \text{ GAL.}^*}{\text{MOL}} = 2.22$ GAL./DAY

OR GAS CONTENT = 0.022 GAL./MMCF

* APPROXIMATE FOR SPONGE OIL VAPOR

Table 2. Calculation Method to Determine Sponge Oil Absorber Equilibrium 200 PSIA and 100° F

BASIS: RESIDUE GAS VOLUME, 100 MMCF/DAY
PERCENT C_{A1} ABSORPTION, 98
THEORETICAL TRAYS, 2.5
AVERAGE CONDITIONS, 200 PSIA AND 100° F

Component	Moles/Day	K	$A = \frac{L}{VK}$	A	Absorbed Moles/Day
Nitrogen	22, 120	62	2.29×10^{-5}	2.29×10^{-5}	0.50
Methane	216, 060	14.3	9.93×10^{-5}	9.93×10^{-5}	21.45
Ethane	16, 330	3.0	4.73×10^{-4}	4.73×10^{-4}	7.72
Propane	7, 110	0.97	1.46×10^{-3}	1.46×10^{-3}	10.38
Butanes	1, 844	0.36	3.94×10^{-3}	3.94×10^{-3}	7.27
C_{A1}	15.15	3.3×10^{-4}	4.3	.98	14.86
C_{A2}	24.16	1.75×10^{-4}	8.11	.995	24.01
C_{A3}	3.14	0.68×10^{-4}	20.9	1.00	3.14
Totals	263, 506.45				89.33

A FOR $C_{A1} = 4.3 = \frac{L}{VK}$

$\frac{L}{V} = 4.3 \times (3.3 \times 10^{-4}) = 1.42 \times 10^{-3}$

FOR AVERAGE $\frac{L}{V}$:

$L = 1.42 \times 10^{-3} \times 263, 506.45 - \frac{89.33}{2} = 329.51 \frac{\text{MOLES}}{\text{DAY}}$

SPONGE OIL RATE:

$329.51 \frac{\text{MOLES}}{\text{DAY}} \times \frac{41.1 \text{ GAL.}}{\text{MOLE}} \times \frac{\text{DAY}}{1440 \text{ MIN}} = 9.40$ GPM

The stripper equilibrium is established utilizing a method presented for reboiled absorbers by Dr. R. N. Maddox at Oklahoma State University.[5] The general steps after establishing feed condition are:

1. Set absorption and stripping efficiencies for key component in both rectifying and stripping sections.
2. Assume average operating conditions for each section.
3. Establish L/V and V/L in the rectifying and stripping sections, respectively, from the desired efficiencies, average conditions, and available theoretical trays.
4. Calculate absorption and stripping factors for each component in each section, and determine fraction absorbed and stripped.
5. Find distillate and bottoms compositions from Equation 1 in Table 3.
6. Back calculate to find liquid leaving bottom rectifying tray (X) and vapor leaving top stripping tray (Y).
7. Check assumed oil and gas ratios.
8. Find temperature of top and bottom trays for each section by bubble point and dew point calculations and check assumed temperatures.
9. Make overall column heat balance.
10. Make heat balances for individual sections.
11. Revise assumed conditions and flow rates and recalculate equilibrium starting with step 4.

If the oil-gas ratios vary substantially through the section, the effective absorption and stripping factors of Edmister[2] should be employed. For a more accurate look at the stripper equilibrium of Table 3, the "effective" factors would be used after the temperatures and heat balances were established.

The system oil and sponge oil distribution through the stripper is better than necessary with only 2.5 gal per day of sponge oil overhead and less than 6 gal per day of system oil in the bottoms. The same volume of stripping gas will adequately strip the sponge oil at double the circulation rate with a small increase in temperature.

4. The Wichita sponge oil unit consists of standard processing equipment in every respect. The type and class of equipment is a matter of personal and company preference. Good unit dependability can be justified because the value of the absorption oil which is lost while the sponge oil unit is down is usually substantial.

One important consideration for unit design is possible mechanical entrainment in the system absorber. The amount of entrainment varies widely depending upon operating conditions, and this variation will add an unpredictable additional load to the sponge oil stripping system. An efficient mist eliminator is highly desirable for both absorbers.

For heavy sponge oils, viscosity will vary between products of the same molecular weight. This characteristic is important in the design of the heat transfer equipment.

5. The sponge oil unit cost can be estimated from past experience, manufacturer's quotations and/or the literature. The operating expenses must be related to normal expenses of the plant involved. The unit earnings depend upon company practices for handling expenses, depreciation, and taxes in establishing a profitability index.

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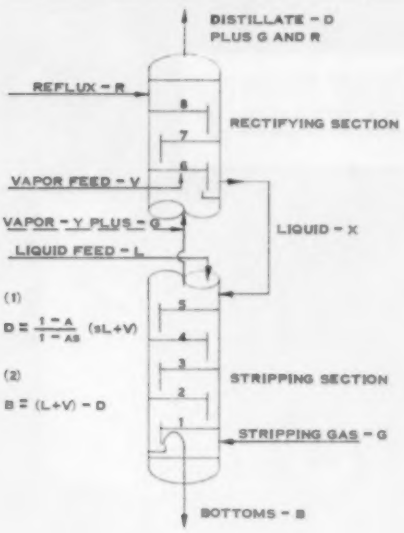
4. Poettman, F. H. and Mayland, B. J., *Petroleum Refiner*, 28, No. 7, 101 (July 1949).
5. Maddox, R. N., Oklahoma State University, Personal Communication.
6. Smith, K. A. and Smith, R. B., *Petroleum Processing*, 4, No. 12, 1355 (December 1949).
7. Souders, Mott, Jr. and Brown, G. G. *Industrial Engineering Chemistry* 24, 519 (1932).

Table 3. Calculation Method to Determine Sponge Oil Stripper Equilibrium

BASIS: SPONGE OIL RATE, 10 GPM
RESIDUE GAS VOLUME, 100 MMCF/DAY
STRIPPING GAS VOLUME, 1.51 MMCF/DAY
REFLUX RATE, 2.4 GPM
FEED CONDITIONS, 60 PSIA AND 375° F
STRIPPING SECTION CONDITIONS, 60 PSIA AND 400° F
RECTIFYING SECTION CONDITIONS, 60 PSIA AND 325° F
THEORETICAL STRIPPING TRAYS, 5
THEORETICAL RECTIFYING TRAYS, 3



FEED FLASH:

COMPONENT	MOLES/DAY	K	LIQUID (L) MOLES/DAY	VAPOR (V) MOLES/DAY
NITROGEN	0.50	500	0.01	0.49
METHANE	21.45	58	3.93	17.52
ETHANE	7.72	26	2.57	5.15
PROPANE	10.38	13.5	5.09	5.29
BUTANES	7.27	7.8	4.54	2.73
C_{A1}	14.86	0.19	14.65	0.21
C_{A2}	24.01	0.14	23.75	0.26
C_{A3}	3.14	0.08	3.12	0.02
C_{S1}	70.07	0.01	70.02	0.05
C_{S2}	210.22	0.0033	210.17	0.05
C_{S3}	70.07	0.0011	70.06	0.01
TOTALS	439.69		407.91*	31.78

*L ASSUMED = 408.28

COLUMN EQUILIBRIUM:

ASSUME: $\frac{L}{V} = 0.02$ FOR RECTIFYING SECTION AND $\frac{V}{L} = 10$ FOR STRIPPING SECTION

	RECTIFYING SECTION			STRIPPING SECTION			$\frac{1-A}{1-AS}$			
COMPONENT	K	A	A	K	S	S	$\frac{1-A}{1-AS}$	SL+V	D	B
NITROGEN	500	.00004	.00004	500	5000	1.00	1.00	.50	.50	.00
METHANE	57	.00035	.00035	58	580	1.00	1.00	21.45	21.45	.00
ETHANE	25	.0008	.0008	28	280	1.00	1.00	7.72	7.72	.00
PROPANE	12.2	.00164	.00164	14.5	145	1.00	1.00	10.38	10.38	.00
BUTANES	6.5	.0031	.0031	8.5	85	1.00	1.00	7.27	7.27	.00
C_{A1}	.10	.20	.20	.28	2.8	1.00	1.00	14.86	14.86	.00
C_{A2}	.071	.282	.282	.21	2.1	1.00	1.00	24.01	24.01	.00
C_{A3}	.038	.526	.487	.12	1.2	.969	.972	3.04	2.95	.19
C_{S1}	.0035	5.71	.996	.017	.17	.17	.0048	11.95	.06	70.01
C_{S2}	.0011	18.2	1.00	.006	.06	.06	.00	12.66	.00	210.22
C_{S3}	.0004	50	1.00	.002	.02	.02	.00	1.41	.00	70.07
TOTALS									89.20	350.49

BACK CALCULATION FOR X AND Y:

RECTIFYING SECTION

$\frac{D+G}{1-A} = V+G+Y$

$(V+G+Y) - (D+G) = X$

STRIPPING SECTION

$\frac{B}{1-S} = L+X$

$(L+X) - B = Y$

COLUMN LOADING AND RATIO CHECK:

	RECTIFYING SECTION								STRIPPING SECTION					
COMPONENT	V	Y	G	V+Y+G	A	X	D+G	R	L	X	L+X	S	Y	B
NITROGEN	0.49	0.02	336	336.51	.00004	.01	336.50		0.01	0.01	0.02	1.00	0.02	
METHANE	17.52	5.09	3280	3302.61	.00035	1.16	3301.45		3.93	1.16	5.09	1.00	5.09	
ETHANE	5.15	2.77	248	255.92	.0008	0.20	255.72		2.57	0.20	2.77	1.00	2.77	
PROPANE	5.29	5.28	108	118.57	.00164	0.19	118.38		5.09	0.19	5.28	1.00	5.28	
BUTANES	2.73	4.65	28	35.38	.0031	0.11	35.27		4.54	0.11	4.65	1.00	4.65	
C_{A1}	0.21	18.37		18.58	.20	3.72	14.86	24	14.65	3.72	18.37	1.00	18.37	
C_{A2}	0.26	33.18		33.44	.282	9.43	24.01	72	23.75	9.43	33.18	1.00	33.18	
C_{A3}	0.02	5.74		5.76	.487	2.81	2.95	24	3.12	2.81	5.93	.969	5.74	0.19
C_{S1}	0.05	14.34		14.39	.996	14.33	0.06		70.02	14.33	84.35	.17	14.34	70.01
C_{S2}	0.05	13.42		13.47	1.00	13.47	0		210.17	13.47	223.64	.06	13.42	210.22
C_{S3}	0.01	1.43		1.44	1.00	1.44	0		70.06	1.44	71.50	.02	1.43	70.07
TOTALS	31.78	104.29	4000	4136.07		46.87	4089.20	120	407.91	46.87	454.78		104.29	350.49

$R = 2.4 \text{ GPM} \times 1440 \frac{\text{MIN}}{\text{D}} \times \frac{\text{MOLE}}{28.75 \text{ GAL.}} = 120 \text{ MOLES/DAY}$

CHECK $\frac{L}{V} = 0.02$ – RECTIFYING SECTION

CHECK $\frac{V}{L} = 10$ – STRIPPING SECTION

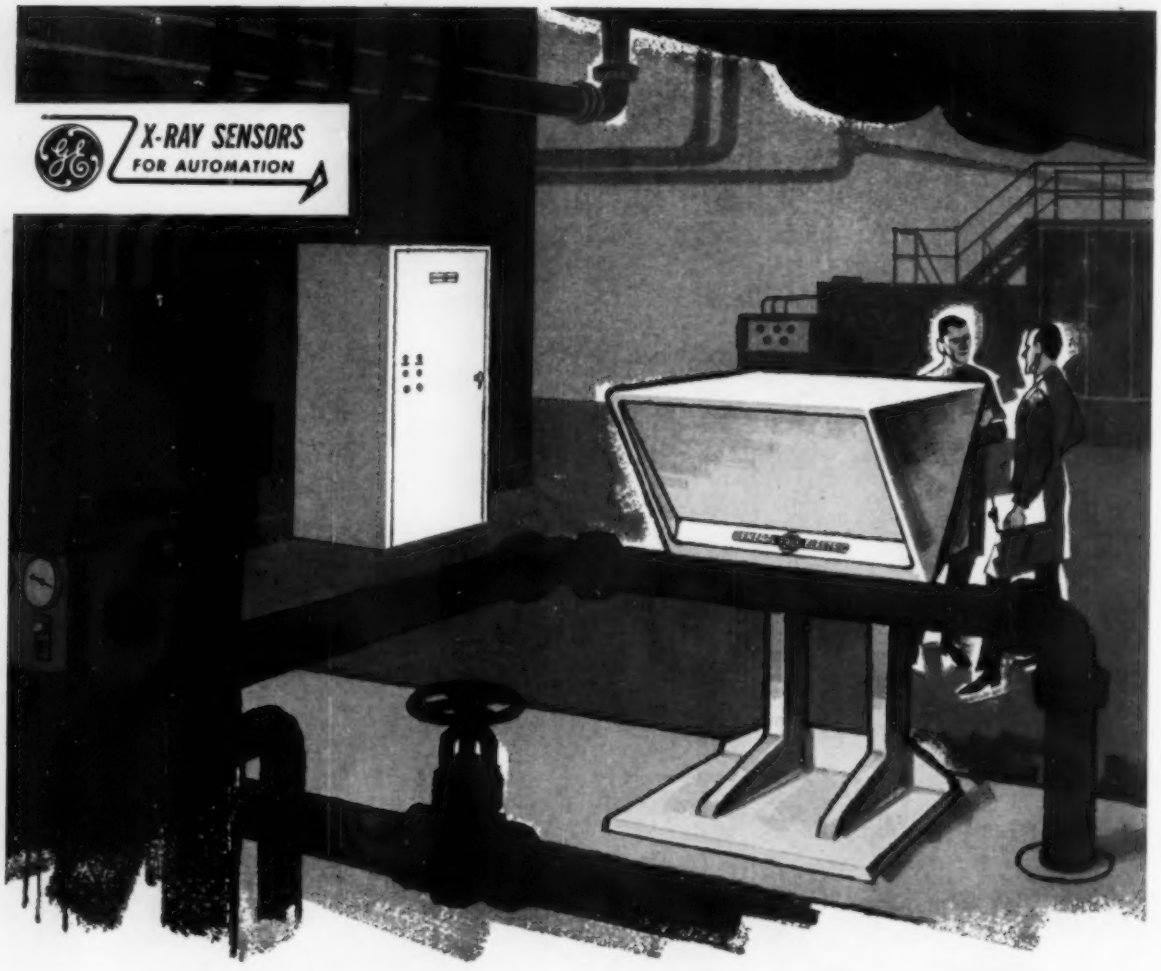
FOR AVERAGE $\frac{R+X}{(Y+G+V)+(D+G+R)} = \frac{120 + 46.87}{4136.07+4209.20}$

FOR AVERAGE $\frac{G+(Y+G)}{(X+L)+B} = \frac{4000+4104.29}{454.78+350.49}$

AVERAGE $\frac{L}{V} = 0.02$

AVERAGE $\frac{V}{L} = 10.06$

★ ★ ★



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GENERAL ELECTRIC

What are the effects of DATA SELECTIONS *on Process Equipment?*

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ONE OF THE MOST BOTHERSOME PROBLEMS facing the engineer designing process equipment is the selection of thermodynamic and physical data. Selection of incorrect or improper data may result in equipment that cannot do the job intended satisfactorily. All too frequently, the engineer gives little thought to the selection of data. He simply uses what is available in the company data file. In many cases, this information is obsolete or out of date.

In order to evaluate some of the effects of data selection on process equipment, data from several sources were used in different solutions of the same process problem. A distillation column was chosen as a basic example because rigorous plate-to-plate solutions can easily be made on a digital computer. For each problem input data remained the same except for a variation in either equilibrium or enthalpy data.

The method of calculation used was that outlined by Erbar and Maddox.[3,4,5] All calculations were carried out on the medium size computer located in the Oklahoma State University Computing Center.

The distillation column selected for study was a depropanizer. The column operated under the conditions outlined in Table 1. A depropanizer was chosen in preference to another tower because the temperature ranges and operating pressure are such that non-idealities should not be great. In addition, towers of this kind are common and the procedure for design should be familiar to most engineers.

The first thing that was done was to establish the data for "base case" calculations. Natural Gasoline Association of America[11] K values were selected because they are widely used in the natural gasoline industry. Enthalpy data presented by the M. W. Kellogg Company in the Natural Gasoline Supply Men's Association Engineering Data Book[11] were chosen for the same reason. This basic data were used in the solution of the first plate-to-plate on the depropanizer. Results of these calculations are shown in Table 2. The overhead composition of 93 percent propane is not quite high enough if design is to be based on commercial (95 percent) propane. However the variation is not great, approximately 2 percent, and seemed close enough to warrant proceeding with the calculations. Any variations resulting from changing property data should be just as valid for this case as they would be if the overhead composition were 95 percent propane.

Equilibrium data were taken from the following sources:

A. NGSMA Engineering Data Book, 1957.[11]
B. NGSMA Engineering Data Book, 1951.[10]
C. NGSMA Data Book, 1951[10] — Pure component vapor pressure converted to equilibrium ratio by dividing by total pressure.
D. Maxwell[8] — Fugacity function for pure component divided by total pressure to obtain equilibrium ratio.
E. Winn.[14]
F. Katz and Hachmuth.[6]

Enthalpy data were taken from the following sources:

1. M. W. Kellogg Company, 1957 NGSMA Engineering Data Book.[11]
2. Mollier Diagrams, Data Book on Hydrocarbons by Maxwell.[9]
3. Schiebel and Jenny — Pure H. C. Enthalpy Nomograph 1951 NGSMA Engineering Data Book.[11]
4. H. C. Mixtures Nomograph 1951 NGSMA Handbook.[10]
5. Brown, Unit Operations:[1] Vapor enthalpy data were corrected for pressure using generalized correction function of Hougen and Watson.[6] Liquid enthalpy data were not corrected.
6. API Project 44,[13] Ideal gas state enthalpies corrected by generalized correlation of $\Delta H/T_c$ presented by Edmister.[2] Liquid enthalpies were obtained by subtracting API 44 values for latent heat of vaporization from the ideal gas state enthalpies.
7. API Project 44,[13] Ideal gas state enthalpies corrected by method of Pitzer and Curl.[12] Latent heats of vaporization were determined by the method of Lyderson, Greenkorn and Hougen.[8] Liquid enthalpies were determined by subtracting latent heats from the corrected vapor enthalpy data.

In all cases, enthalpies were determined for the pure hydrocarbons. Stream enthalpies were calculated as the mole average of the pure component enthalpies. Where necessary the enthalpy data were converted to Btu/lb mole prior to using the data in any calculations.

DISCUSSION INVITED . . . the authors of papers appreciate comments and discussion from the readers. Please address your replies . . . for publication or to be directed to the authors . . . to **J. C. Webb, Editor, P. O. Box 1589, Dallas 21, Texas**

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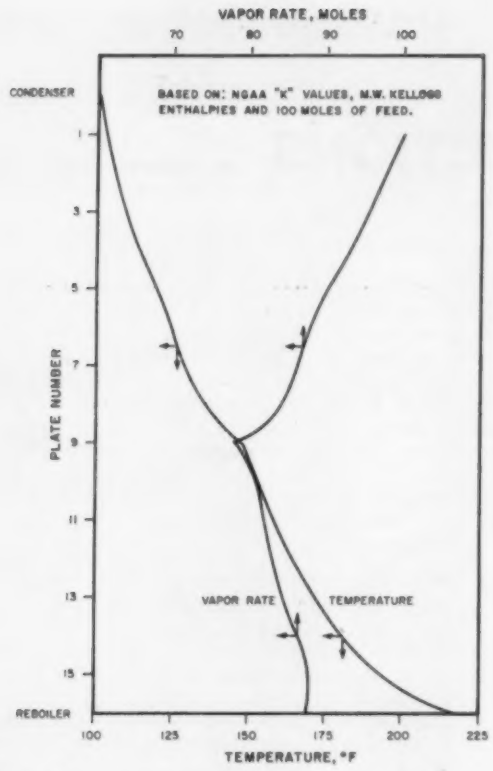

FIG. 1. Vapor rate and temperature profiles.

Combinations of different enthalpy and equilibrium data will be referred to by subscripts according to their listing, i.e., $K_A H_I$ would refer to calculations based on NGAA 1957 equilibrium values and M. W. Kellogg enthalpy values.

Results of the plate-to-plate calculations are shown in Fig. 1 and Tables 2 to 9. They will be discussed in detail below.

Temperature profiles are shown in Tables 3 and 4. As would be expected, changes in enthalpy values do not greatly affect the temperature profile in the column. Temperatures are largely dependent on stream composition. Stream compositions are dependent on fractionation occurring in the column. A peculiarity of enthalpy data is that though absolute values of enthalpy may differ considerably, enthalpy differences generally are fairly close to each other. Since most heat load calculations actually involve differences, rather than individual values, it is not unexpected that there is little difference caused by changing enthalpy values in the column.

The effect of changing equilibrium data on the temperature profile is shown in Table 4. As would be expected, the variation is greater than for different values of enthalpy. Changing the equilibrium data changes component distributions in the column, and so occasions larger differences in the temperature profile.

Vapor profiles for the different columns are shown in Tables 5 and 6. The variations in vapor loading for different enthalpy data are shown in Table 5. The individual variations are not great. The maximum variation for any plate in the column is of the order of ten percent. Normal safety factors used in design would provide an adequate margin of safety for this magnitude of error.

Variations of vapor loading for changing equilibrium data are shown in Table 6. Here the variations in the top of the column are not so great as for different enthalpy data. The variations in the bottom of the column become more serious and in some cases could exceed the limits of a design safety factor. Deviations of more than 20 percent occur and this could prove to be a serious factor if a column were designed on the conservative side.

Variations in product compositions are shown in Tables 7 and 8. In studying these compositions, variations in minor components must be considered in order to obtain the true impact of the data. For example, in Table 7, changing enthalpy data causes a variation of propane concentration from 93.087 percent to 94.056 percent. This is a variation of slightly more than 1 percent. If we consider

TABLE 1. Feed Composition and Tower Parameters.

	Feed Comp	Feed Mole %
Ethane	C_2	0.271
Propane	C_3	26.695
iso Butane	iC_4	8.923
normal Butane	nC_4	34.170
iso Pentane	iC_5	8.863
normal Pentane	nC_5	9.992
Hexane	C_6	8.017
Heptane	C_7	3.069
		100.000

Tower Pressure	200 psia
Feed Temperature	150° F.
Number of Theoretical Plates	15
Reflux Ratio (L_o/D)	2.7
Feed Plate Number	9

TABLE 2. Result of Calculations Based on Calculations Using NGAA K Values, M. W. Kellogg Enthalpies and 100 Moles of Feed.

Comp	Distillate Moles	Distillate Mole %	Bottoms Moles	Bottoms Mol %
C_2	.271	1.009	-	-
C_3	24.995	93.089	1.696	2.319
iC_4	1.206	4.492	7.717	10.550
nC_4	.379	1.410	33.791	46.197
iC_5	-	-	8.863	12.117
nC_5	-	-	9.992	13.660
C_6	-	-	8.017	10.961
C_7	-	-	3.069	4.196
	26.855	100.000	73.145	100.000

PROFILES

	Temperature of	Vapor Rate Moles
Condenser	101.2	-
1	103.3	100.0
2	105.8	98.0
3	109.3	95.5
4	113.9	92.7
5	119.1	90.2
6	124.3	88.1
7	129.4	86.6
8	135.6	84.9
9	148.1	78.4
10	152.6	81.4
11	158.3	82.1
12	165.1	83.1
13	172.8	84.7
14	181.4	86.8
15	192.9	88.6
Reboiler	216.6	68.0

Condenser Load 5.77×10^4 Btu.

Reboiler Load 7.50×10^5 Btu.

TABLE 3. Temperature Profiles Based on Calculations Using NGAA K Values and Various Enthalpies.

Plate No.	Temperature °F					
	H_2	H_3	H_4	H_5	H_6	H_7
Condenser	101.1	101.2	101.1	101.1	101.2	101.0
1	103.1	103.2	103.1	103.0	103.2	102.8
2	105.5	105.7	105.5	105.3	105.7	104.9
3	108.9	109.2	108.9	108.6	109.2	107.9
4	113.3	113.6	113.4	112.9	113.8	112.1
5	118.5	118.6	118.6	118.0	119.2	117.2
6	123.8	123.7	123.9	123.3	124.7	122.8
7	129.1	128.8	129.2	128.7	130.0	128.6
8	135.5	135.0	135.5	135.1	136.3	135.3
9	148.2	147.7	148.2	147.8	148.6	148.2
10	152.9	152.1	153.0	152.4	153.4	153.2
11	158.8	157.8	158.9	158.2	159.2	159.4
12	165.7	164.6	165.9	165.2	166.1	166.6
13	173.5	172.4	173.6	173.0	173.8	174.4
14	182.1	181.1	182.2	181.7	182.3	182.9
15	193.5	192.8	193.5	193.3	193.6	194.2
Reboiler	217.1	216.9	217.0	217.5	217.1	217.9

TABLE 4. Temperature Profiles Based on Calculations Using M. W. Kellogg Enthalpies and Various "K's".

Plate No.	Temperature °F				
	K_b	K_c	K_d	K_e	K_f
Condenser	102.2	100.6	102.6	101.3	102.1
1	104.7	101.6	105.4	102.9	104.1
2	107.9	102.6	109.3	104.9	106.7
3	112.2	105.0	114.7	108.0	110.7
4	117.4	110.1	121.3	112.4	116.5
5	122.6	118.3	128.4	117.7	123.6
6	127.2	127.4	135.1	123.1	131.1
7	131.6	135.0	141.5	128.3	138.4
8	137.3	141.9	149.6	134.5	146.8
9	150.4	156.7	166.9	147.9	162.4
10	154.9	170.5	174.6	154.3	169.2
11	160.6	185.1	184.5	162.1	177.5
12	167.6	198.4	196.0	170.8	186.8
13	175.5	210.2	208.3	180.0	196.5
14	184.8	223.0	220.7	189.7	206.3
15	197.7	246.1	235.0	202.5	218.5
Reboiler	223.7	300.0*	256.5	228.1	240.8

* Upper limit of temperature as defined by input data to computer.

TABLE 5. Vapor Profiles Based on Calculations Using NGAA "K" Values and Various Enthalpies.

Plate No.	Vapor Rate, Moles					
	H_2	H_3	H_4	H_5	H_6	H_7
Condenser	-	-	-	-	-	-
1	100.0*	100.0*	100.0*	100.0*	100.0*	100.0*
2	98.5	97.5	98.4	98.7	99.4	99.7
3	96.5	94.5	96.2	96.8	98.1	98.9
4	94.2	91.3	93.8	94.4	96.2	97.7
5	91.9	88.7	91.5	92.1	93.9	96.1
6	89.9	86.9	89.6	90.2	91.7	94.2
7	88.3	85.6	88.1	88.6	89.6	92.5
8	86.5	84.5	86.5	86.9	87.3	90.3
9	80.0	79.4	80.3	79.5	78.0	80.9
10	83.0	82.3	83.0	83.9	82.4	86.2
11	84.0	83.4	83.7	85.6	83.1	87.7
12	85.2	85.1	84.8	87.8	84.2	89.8
13	87.0	87.5	86.4	91.0	85.9	92.7
14	89.2	90.5	88.3	94.7	88.1	96.0
15	91.0	93.3	89.7	98.7	90.1	98.9
Reboiler	89.9	93.3	88.4	97.9	89.1	98.5

* Value specified by input data.

TABLE 6. Vapor Profiles Based on Calculations Using Kellogg Enthalpies and Various "K" Values and 100.0 Moles Feed.

Plate No.	K_b	K_c	K_d	K_e	K_f
Condenser	-	-	-	-	-
1	100.0*	100.0*	100.0*	100.0*	100.0*
2	97.6	99.2	97.5	98.2	98.5
3	94.6	97.5	94.4	95.7	96.1
4	91.7	94.1	91.3	92.7	93.0
5	89.4	89.4	88.8	89.7	90.0
6	87.8	85.6	87.2	87.4	87.5
7	86.6	83.7	86.0	85.8	85.7
8	85.2	82.4	84.4	84.2	83.9
9	77.9	78.1	74.7	77.4	76.7
10	81.7	82.1	81.5	81.0	80.9
11	82.6	87.3	84.4	82.3	82.7
12	83.8	94.3	88.1	84.4	85.2
13	85.6	101.6	93.2	87.2	88.7
14	87.8	107.9	98.9	90.5	92.5
15	89.7	110.9	104.1	93.2	95.8
Reboiler	89.4	109.8	106.7	93.1	96.2

* Value specified by input data.

the iso-butane, however, the variation is from 4.492 percent to 3.890 percent or a variation of 15 percent of the quantity of iso-butane involved. For normal butane, the variation is from 1.410 percent to 1.048 percent, or a variation of about 35 percent of the quantity of normal butane involved.

Product variations for changing equilibrium data are even more serious. The propane concentration varies from 91.802 percent to 98.195 percent or a change of approximately 9 percent. The iso-butane concentration varies from 4.982 percent to 0.337 percent, and the normal butane concentration varies from 2.568 percent to 0.458 percent. Variations of this magnitude could cause serious errors in the estimation of product recoveries.

Looking at the bottom temperatures calculated from different data, we find a temperature difference of over 80 deg in the reboiler temperature predicted. This extreme variation is occasioned by use of uncorrected vapor pressure equilibrium data (Problem K_cH_1). If we assume that no one will use uncorrected vapor pressures, and consider only those systems of data that involve some correction for composition, temperature or pressure, we still find a 40 deg variation in reboiler temperature. In many instances, this magnitude of temperature error would cause a severe loading problem on the reboiler for the column.

Condenser and reboiler heat duties are shown in Table 9. There is little difference in the condenser load. Examination of the temperature profiles shows that there is little variation in top tray and condenser temperatures for any of the equilibrium values. There is a change in composition, but the predominant component in all cases is propane. In addition to this, the total mols of distillate and reflux are held constant by input restrictions on the plate-to-plate program. Also, the same enthalpy data was used for all heat balance calculations. For these reasons, one would expect little change in the condenser heat loads calculated.

The reboiler loadings in Table 9 for changing equilibrium data indicate a maximum variation of approximately 40 percent. This is a rather serious difference and can be explained by the fact that there is no restriction on vapor rate boil up and the fact that reboiler temperatures differ widely. Problem K_cH_1 gave the highest value for reboiler loading and a check of the temperature profiles shows that this problem also had much the highest reboiler temperature. Since the equilibrium data used in this is based on uncorrected vapor pressures, it probably does not represent a typical industrial solution. All of the other cases have 20 percent or less error in reboiler load. Normal design safety factors would probably more than cover variations of this magnitude.

Table 9 also shows the variations in condenser and reboiler loadings calculated using NGAA K values for all cases but changing the enthalpy data source. Here again there is little change in composition and no change in total moles of distillate and reflux. The plus or minus 20 percent change in condenser loading is occasioned by changing the enthalpy data source. Changes of this magnitude might or might not be covered by design safety factors. These differences do point out the importance of enthalpy data selection even at moderate temperatures and pressures.

The reboiler loads in Table 9 also differ by approximately plus or minus 20 percent. There is a consistency in the source of enthalpy data. Table 9 shows that an enthalpy source which calculates a high value of condenser duty will also calculate a high value of reboiler duty and that the reverse is true also. This means that an engineer, using the same data in all calculations, after a little experience and checking some of his design calculations, will probably be able to arrive at safety factors to adequately cover errors in his basic enthalpy data.

The foregoing discussion of differences in values calcu-

TABLE 7. Product Compositions Based on Calculations Using NGAA "K" Values, Various Enthalpies and 100 Moles of Feed.

Compositions Mol %

Component	H_2		H_3		H_4	
	Dist	Btms	Dist	Btms	Dist	Btms
C_2	1.009	-	1.008	-	1.008	-
C_3	93.088	2.153	93.184	2.221	93.345	2.178
iC_4	4.492	10.623	4.429	10.577	4.340	10.609
nC_4	1.410	46.269	1.378	46.240	1.306	46.259
iC_5	.001	12.123	.001	12.125	.001	12.123
nC_5		13.668		13.670		13.667
C_6		10.966		10.968		10.966
C_7	-	4.198		4.199		4.198
Moles	26.894	73.106	26.905	73.095	26.892	73.108

Component	H_5		H_6		H_7	
	Dist	Btms	Dist	Btms	Dist	Btms
C_2	1.006	-	1.006	-	1.006	-
C_3	93.603	2.016	93.195	2.160	94.056	1.841
iC_4	4.177	10.673	4.448	10.574	3.890	10.780
nC_4	1.213	46.327	1.350	46.279	1.048	46.391
iC_5	.001	12.132	.001	12.133	-	12.133
nC_5	-	13.677	-	13.678	-	13.678
C_6	-	10.974	-	10.975	-	10.975
C_7	-	4.201	-	4.201	-	4.201
Moles	26.945	73.055	26.951	73.049	26.952	73.048

TABLE 8. Product Compositions Based on Calculations Using Kellogg Enthalpies, Various "K" Values and 100 Moles of Feed.

Component	K_b		K_c		K_d	
	Dist	Btms	Dist	Btms	Dist	Btms
C_2	1.008	-	1.010	-	1.006	-
C_3	91.856	2.735	98.195	.456	91.804	2.696
iC_4	4.567	10.525	.337	12.074	4.982	10.375
nC_4	2.568	45.789	.458	46.541	2.207	45.951
iC_5	.001	12.122		12.116	.001	12.130
nC_5		13.666		13.659		13.675
C_6		10.965		10.959		10.972
C_7		4.198		4.195		4.200
Moles	26.885	73.115	26.846	73.154	26.933	73.067

	K_e		K_f	
	Dist	Btms	Dist	Btms
	1.009	-	1.013	-
	94.876	1.658	95.524	1.543
	3.145	11.045	2.638	11.219
	.969	46.362	.824	46.355
		12.118		12.102
		13.661		13.643
		10.961		10.947
		4.196		4.191
Moles	26.858	73.142	26.762	73.238

TABLE 9. Condenser and Reboiler Loads, Basis: 100 Moles Feed.

Data	Reboiler Load Btu X 10^{-5}	Condenser Load Btu X 10^{-4}
K_aH_1	7.49	5.77
K_aH_2	7.73	6.03
K_aH_3	7.83	6.19
K_aH_4	7.71	6.09
K_aH_5	6.23	4.54
K_aH_6	6.76	4.90
K_aH_7	9.03	6.54
K_bH_1	7.67	5.79
K_cH_1	10.54	5.64
K_dH_1	8.21	5.79
K_eH_1	7.93	5.72
K_fH_1	7.76	5.70

lated from different thermodynamic data has assumed accuracy of "base case" results. If other data are assumed correct, different evaluations will result. Consider, for example, the result if problem K_aH_5 is considered to give the correct value for reboiler loading. Problem K_aH_7 deviates from this by almost 50 percent. One should not expect a design safety factor to provide for this margin of error.

The data presented here show that the choice of enthalpy and equilibrium data can have an appreciable effect on the distillation column design that results from process calculations. **No attempt has been made to evaluate the accuracy of any data.** The intent has been to point out to engineers a problem of which they may not have been aware. This work does show that need for better enthalpy and equilibrium data still exists.

Acknowledgment

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* * *

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Dr. Erbar, *now with Standard of California in Richmond, received his BS, MS and PhD in Chemical Engineering at Oklahoma State University. His experience includes two years with U. S. Army and short periods in the Natural Gas Department of Magnolia and the Engineering Department of B.S.&B. He is a member of AIChE, Sigma Tau and Sigma Xi, and was recipient of the DX-Sunray Oil Company Fellowship in Chemical Engineering at Oklahoma State.*

Martha L. Stocking, *a senior at Stillwater, Oklahoma, High School, last summer was one of four high school students who carried out research projects on Oklahoma State University's 650 computer under a National Science Foundation program. Her project was a study of the effects of equilibrium constant and enthalpy values on distillation separations. Martha, a finalist in the National Merit Scholarship competition, plans to major in mathematics and to become a university math teacher after completing the PhD degree.*

Catalytic Isomerization

Licensed by: Phillips Petroleum Company

DESCRIPTION: The dry normal butane feedstock is first vaporized and superheated and then, after being mixed with recycle HCl vapors, is fed to a pretreater. The pretreated feed next passes to the reactor.

The pretreater and reactor are bed type chambers containing aluminum chloride sublimed on bauxite. The reactor effluent, consisting of isobutane, normal butane and trace side reaction products, passes through a bauxite-filled guard chamber and then is condensed in a series of effluent exchangers. Removal of trace noncondensables from the liquid effluent stream is performed in a vent gas absorber and HCl vapor is removed by stripping. HCl vapor overhead from the stripper is recycled to the feed pretreater.

The bottoms product from the stripper passes through a caustic washer and sand filter before being charged to the fractionation section which consists of a deisobutanizer and a deoiler tower. High purity isobutane is yielded as an overhead product from the deoiler is recycled to the driers. A small quantity of pentane and heavier production is yielded as a bottom product of the deoiler tower.

Addition of catalyst to the system is accomplished by subliming aluminum chloride with the hot feedstock and depositing it on the bauxite in the pretreater and the reactor. Make up HCl is injected into the system down stream of the effluent exchangers.

APPLICATION:

Isomerization of normal butane to produce a high-yield, high-purity isobutane is performed by a vapor phase catalytic treatment of dry normal butane wherein the catalyst utilized is aluminum chloride promoted with HCl.

YIELDS:

Typical process information is presented in the following tabulations:

BASIS:

100 barrels of charge — 50 per cent conversion per pass.

	Charge (Bbl.)	Isobutane Yield (Bbl.)	Deoiler Bottoms (Bbl.)	Vent Gas (s.c.f.)
Ethane and Lighter	—	—	—	Trace
Propane	—	5	—	—
Isobutane	2	85	—	—
Normal Butane	96	2	—	—
Pentane plus	2	—	8	—
	100	92	8	—

Utilities (Unit/Bbl. Isobutane Produced):

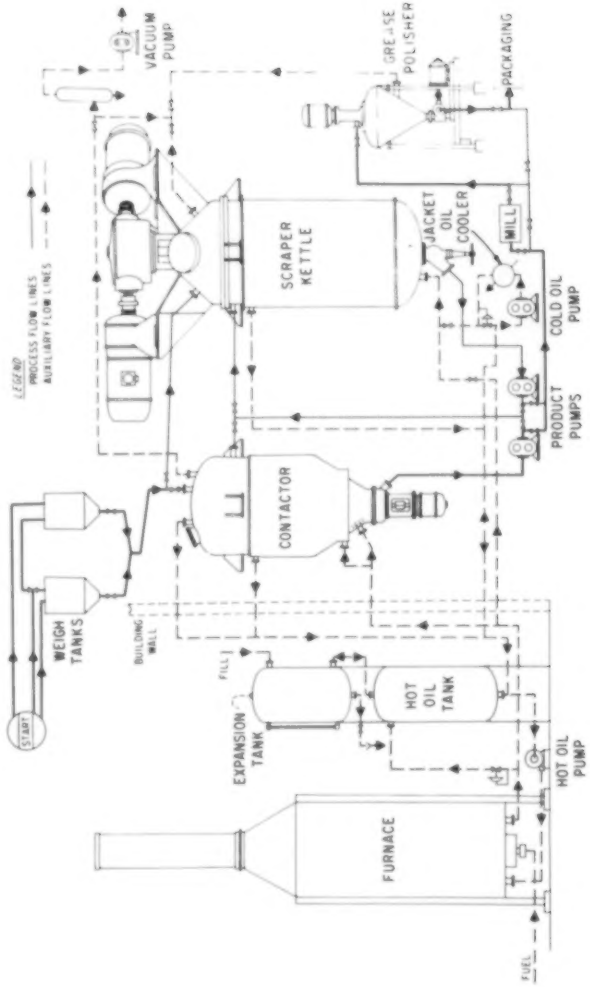
Water circulation, 1,000 gallons	1.5
Water Make-up, 1,000 gallons	0.045
Power, Kw-Hr	1.54
Steam, 1,000 lb.	0.680

Chemicals (Lb./1,000 Bbl. iC_4 Produced):

Aluminum chloride	85
HCl	70
Bauxite	440
Driocel for driers	7
Caustic	89

Stratco Grease Manufacturing

Licensed by: Stratford Engineering Corporation



Stratco Grease Manufacturing

Licensed by: Stratford Engineering Corporation

DESCRIPTION: The process involves accurate weight control of all feed components, intimate mixing, rapid heating and cooling, together with milling, dehydration and deaeration, whenever required. The major process equipment consists of an oil circulation heater, high dispersion contactor, scraper kettle and a grease polisher.

The soap is prepared by charging weighed quantities of ingredients to the Stratco contactor. The reaction is conducted at uniform temperature through the circulation of a hot oil through the shell and circulation tube jackets of the contactor. Time cycles of only 30 minutes are required to complete the saponification reaction and excess water may be removed simultaneously through a vacuum line, if desired. The remainder of the oil and additives may then be charged into the contactor to complete the manufacture of the grease, or the soap may be transferred into a scraper kettle where these ingredients are added and the grease is finished to specification. The heavier types of grease are normally finished in the scraper kettle due to the high viscosity which prevails at finishing temperatures.

The hot oil circulation pump provides 400°F to 600°F hot oil to the jacket on the heating cycle. On the cooling cycle the cold oil jacket pump is employed recycling jacket oil through the cooler.

The finished grease from either the contactor or scraper kettle may be packaged directly or further processed in a grease mill and grease polisher, as required by the specifications of the final product. A typical time cycle required for the manufacture of calcium type grease is 1-½ to 2 hours, and for soda base grease, approximately 2 to 3 hours.

Pilot size equipment is normally used in conjunction with the commercial equipment for the purpose of plant guidance and the development of new and improved grease formulations.

APPLICATION:

The process is applied to the manufacture of a wide range of lubricating grease.

CHARGE:

Various compounds of fatty acids and alkali earth metals to form a soap, together with petroleum oils or other materials.

PRODUCTS:

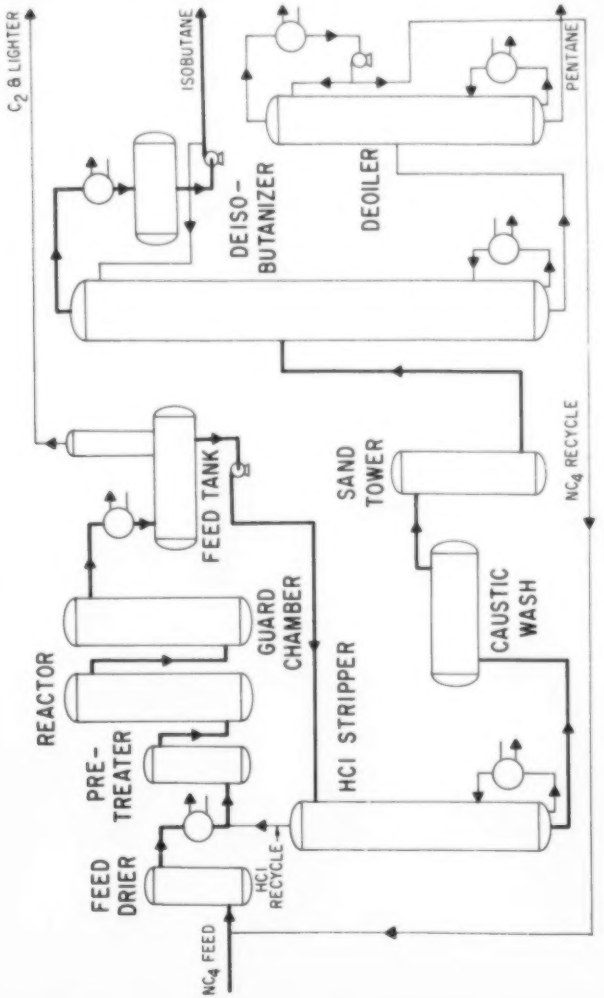
Lubricating grease such as calcium, soda, lithium, barium, aluminum, mixed-base and non-soap base grease of desired specifications.

COMMERCIAL INSTALLATION:

Many installations of the described type have been in operation for a number of years, both in this country and abroad.

Catalytic Isomerization

Licensed by: Phillips Petroleum Company



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DISTILLATION . . .

in View of Modern Developments

a series on recent developments in distillation and absorption techniques

Part II: Distillation
Chapter 2b Theory of Fractionation — Computers

Kenneth F. Gordon
University of Michigan
Ann Arbor, Michigan

James A. Davies
Texaco Inc.
New York City

DURING THE PAST DECADE computers have left the role of an exotic research tool with the digital computer in particular becoming an everyday auxiliary for calculations along with the slide rule and desk calculator. The future of computers is indicated by their role in education. At one university all chemical engineering students from the junior year onward are required to program and use a computer for solving some of their class problems.

Analog computers are used in the study of control problems, they have little application in the usual distillation and absorption problems. Therefore digital computers will be considered for the most part. It is to be emphasized that those problems which recur are the ones which should be put on a computer for the effort yields continuous dividends in time and money saved.

Digital computers. Descriptions and their utilization have been covered in a number of publications by the manufacturers.[2,16,19] Their use is not difficult; an average chemical engineering junior student can learn to program, using the Generalized Algebraic Translator routine (GAT),[5] in about 20 hours becoming proficient enough to make his own simple programs with only an occasional question. However a complex routine like a multicomponent program required nine man months of programming effort by experienced people. It is understood that much of the time was used in the mathematical analysis of the problem. This points out the need for considerably more mathematical training for chemical engineers. Some universities now require undergraduates to take as much mathematics as was required for a doctorate 10 years ago.

Programs

Various companies have developed their own programs for the solution of problems which recur. A number of these are available on cards, punch tapes or magnetic tape.

Some programs available from the various manufacturers are:

1. Continuous Steady State Fractional Distillation with Side Streams and Multiple Feeds
2. Equilibrium Flash Vaporization
3. Batch Distillation without a Fractionation Column
4. Plate to Plate Distillation Calculations
5. Distillation Tower Design by Shortcut Methods
6. Determination of Constants for the Benedict-Webb-Rubin Equation of State and the Computation of Thermodynamic Properties and Phase Behavior from that Equation.

By contacting the manufacturers the latest information on available programs may be obtained. In May 1959, a regular interchange and abstract feature for computer programs was inaugurated in a monthly journal.[21] Two programs on tray hydraulics in bubble cap tray design were covered in June. The universities also develop programs in their thesis research topics. Ravicz,[13] for example, has developed a plate routine for absorbers using efficiencies for both heat and mass transfer.

Multicomponent Distillation

The giant problem of multicomponent distillation has been the subject of several recent articles and programs. At least three distinctly different approaches have been used in employing digital computers. Rose, Sweeney, and Schrodt [17] have developed a new technique involving a relaxation method which is an extension of the calculation of batch distillation with appreciable holdup. Over a short time interval a material balance is made on each plate including the change in concentration of the plate liquid holdup. At the beginning, the composition of each plate is assumed. For all plates this conveniently can be the feed composition. The material balance on each plate is independent of all the others. At the end of the time interval for the first balance the compositions of the liquid on each plate are different and have changed slightly. The material balance is then repeated over and over again until all concentrations are leveled out and do not change with the iteration number or time. Interestingly enough the article shows that in a ternary system the composition of a component may decrease and then increase with the iteration number or time before the concentration levels out. The rate of approach to steady state initially is rapid but becomes extremely slow so that it was suggested that the computation time be shortened by extrapolating the concentration versus time (or iteration) curve. This can be included as part of the program.

The second approach, by Amundson and Pontinen,[1] in a sense may be regarded as a solution of the material balance equation for each component around each plate without the restriction of $\Sigma y = \Sigma Kx = 1$. The program then uses a new method to correct the temperature on each plate so as to bring $\Sigma y = 1$. This program involves a matrix inversion technique.

Another approach is that of Greenstadt, Bard and Morse [6] who worked their way up from the bottom and down from the top of a column starting with assumed end conditions which will result in a mismatch at the mesh plate. The end conditions are corrected by Newton's method to reduce the mismatch to a predetermined acceptable value. This technique will handle up to about 20 components for any number of stages. A 14 component, 13-stage problem ran about 12 minutes on a large high speed computer.

Computer Techniques

Earlier this year a collection of 12 papers on computer techniques of interest to the chemical engineer was published. Of particular interest to distillation engineers are two papers on the calculation of vapor-liquid equilibrium K values, four concerned with multicomponent distillation calculations, one with a non-ideal ternary, one on a graphical distillation calculation technique and one on the application of an analog computer to steady state multicomponent distillation calculations. Also included are more general articles on computers for management control [7] and in large chemical companies.[8,10]

In one [4] of the papers the Edmister and Ruby correlations for K value have been fitted by regression equations involving 19 empirical constants. In another,[16] the Benedict-Webb-Rubin equation of state has been analyzed for accuracy in representing the methane-ethane-propane system. Because of the serious deviation at lower temperatures and higher pressures a DePriester correlation was made.

An analog computer [14] has been used to calculate a steady state extractive distillation of acetylene, carbon dioxide, ethane and ethylene using dimethyl formamide as the added agent. As enthalpy balances are used there is no assumption of constant molal flow rates. Comparison with results calculated by hand and by a computer are favorable. The error of the components present in the greatest concentration, carbon dioxide and dimethyl formamide, was usually about 0.2 percent with the maximum 0.7 percent.

There is an article by Rose et al [18] on the calculation of the number of plates required for a non-ideal ternary. In a paper not directly concerned with computers Hengstebeck [9] has expanded his graphical method for multicomponent systems to handle two feed streams or a side stream.

Bonner [3] has described the system used at a large refinery for distillation calculations. A floating decimal allows individual component rates as low as 10^{-50} mole per hour so that all components may be carried, removing the usual distinction between distributed and non-distributed components and sharp and sloppy separations. They find that rough approximations are satisfactory for initial conditions. The results after the first trial are usually more precise than can be estimated. The composition, temperature and flow rate profile throughout the tower are given by the calculation with 10 to 20 components and 30 to 50 theoretical stages. About 1½ hours of computer time are required as compared to a desk calculator computation of 100 to 200 hours. A short cut method reduces computer time to about 10 minutes.

Two articles [11,12] describe successful computer programs for multicomponent fractionator design. One is for a predetermined number of stages and the other article is for a predetermined separation. Use is made of the delta point concept of the Ponchon-Savarit method, that is the net enthalpy flux and the material flux for each component is constant in any section of the column. In the method for the given number of stages the concentration of all components are carried for all trays.

A number of articles on computers and distillation or mass transfer appear each year. Interested engineers should continually read the current technical literature[20] to keep abreast of rapidly moving developments.

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ERRATA

DISTILLATION IN VIEW OF MODERN DEVELOPMENTS

Please note these corrections to typographical errors appearing in the July, 1959 issue of this series as follows:

Eqn (9), page C-11 should read

$$\frac{f^{\circ}_{L,p^{\circ}}}{f^{\circ}_{L,P}} = e^{\frac{\bar{V}}{RT}(p^{\circ}-P)}$$

Eqn (10), page C-11 should read

$$\gamma_V y f_{V,P} = \gamma_L x f^{\circ}_{L,P} = \gamma'_L x f^{\circ}_{L,p^{\circ}}$$

Below Eqn (12), page C-12 should read

$$y_A f^{\circ}_{A,P} = x f^{\circ}_{A,p^{\circ}}$$

Eqn (13), page C-12 should read

$$p_A = \gamma'_{A,L} p^{\circ}_A x_A = H' x_A = \frac{H'}{\rho_M} c_A = H c_A$$

Eqn (14), page C-12 should read

$$y = \frac{\gamma_L}{\gamma_V}\frac{f^{\circ}_{A,L,P}}{f^{\circ}_{A,V,P}} x = \frac{\gamma'_L f^{\circ}_{A,L,P^{\circ}}}{\gamma_V f^{\circ}_{A,V,P}} x = Kx$$

Eqn (19), page C-13 should read

$$= \frac{\gamma'_{A,L} f^{\circ}_{A,L,p^{\circ}}}{\gamma_{A,V} f^{\circ}_{A,V,P}} \bullet \frac{\gamma_{B,V} f^{\circ}_{B,V,P}}{\gamma'_{B,L} f^{\circ}_{B,L,p^{\circ}}}$$

Below Eqn (45), page C-17 should read

AT $X_1 = 0$ LOG $\gamma_1 = A_{12}$ AT $X_2 = 0$ LOG $\gamma_2 = A_{21}$

LOG $\gamma_2 = 0$ LOG $\gamma_1 = 0$

HELPFUL WATER CONDITIONING DATA FROM BETZ

RETURN LINE CORROSION

Causes of corrosion can be readily identified and economically corrected.

Corrosion in the condensate return lines of boiler systems is a frequent problem. To properly prescribe a solution to the difficulty, it is necessary to determine the primary cause of the attack. Prompt elimination of serious return line corrosion is certainly most advisable since necessary maintenance and replacement of pipe and fittings can be quite costly.

By far the most common causes for return line corrosion are the presence of either oxygen or carbon dioxide, or both of these gases dissolved in the condensate. The appearance of the corroded sections will be a good indication of the cause. An attack by carbon dioxide will be characterized by an actual thinning of the metal wall of the pipe, with associated grooving of the metal. Such attack is illustrated in Figure 1.

Figure 1—Grooving attack by CO_2 is shown in this end view of the condensate pipe.

Corrosion by dissolved oxygen will be evident by a series of pits, usually accompanied by deposits of the reddish colored iron oxides. Such attack may be observed in Figure 2. It is not uncommon to see the results of attack which is due to both oxygen and carbon dioxide. The appearance of such sections will have the combined characteristics of oxygen pitting and carbon dioxide corrosion grooving.

Figure 2—Oxygen pitting attack, distinctly different from CO_2.

Oxygen Attack

Oxygen in steam and condensate may originate directly from the boiler feedwater or may enter at various points in the condensate system. Boiler water makeup will contain appreciable quantities of dissolved oxygen, especially if taken from a surface supply. Since the solubility of dissolved oxygen decreases with increasing temperature, when the feedwater undergoes an increase in temperature in the boiler itself, the dissolved oxygen will be liberated and passed over with the steam. This fact makes the use of an open or deaerating heater of utmost importance in good engineering design of a boiler plant. With such an installation, the major portion of the oxygen in the water will be removed before the water enters the boiler.

The use of an open or deaerating heater removes the oxygen by mechanical deaeration of the boiler feedwater. Since mechanical deaeration is not successful in removing 100% of the dissolved oxygen present, the feed of a chemical deaerant is economically justified to assure that the last traces of the dissolved oxygen are removed. Ordinarily, sodium sulfite (Na_2SO_3) is used for this purpose.

Recently, hydrazine (N_2H_4) has been applied to achieve oxygen removal. The use of hydrazine is usually confined to high pressure installations where the concentration of dissolved solids is critical. Unlike sodium sulfite, hydrazine does not increase the solids of the boiler water.

Oxygen attack can take place not only due to inefficient deaeration of the feedwater, but also through the possibility of oxygen leakage into the condensate. Air infiltration can be expected at condensate pumps, or other points in the system where air may come in contact with the condensate. This potential difficulty can be checked by conducting dissolved oxygen tests on the condensate itself. If it is determined that oxygen is present in the condensate, appropriate mechanical steps can be taken to eliminate or minimize oxygen infiltration.

Carbon Dioxide Attack

Carbon dioxide is the most prevalent cause of return line corrosion, and its source is primarily the feedwater. An open or deaerating heater will remove any free carbon dioxide from the feedwater, but such removal will not eliminate the presence of carbon dioxide in the steam. Since bicarbonates and carbonates present in boiler feedwater will undergo decomposition at elevated temperatures to form carbon dioxide, the result of this decomposition is the chief source of carbon dioxide in the steam. The reactions are as follows:

(1) $2NaHCO_3 + \text{heat} \rightarrow Na_2CO_3 + CO_2 + H_2O$

bicarbonate + heat → carbonate + carbon dioxide + water

(2) $Na_2CO_3 + H_2O + \text{heat} \rightarrow 2NaOH + CO_2$

carbonate + water + heat → hydroxide + carbon dioxide

While reaction (1) will proceed to 100% completion, the decomposition indicated in reaction (2) proceeds to only about 80% completion. All other things being equal, the higher the carbon dioxide content of the steam, the greater will be the corrosion potential. The severity of the anticipated attack may be roughly estimated by conducting

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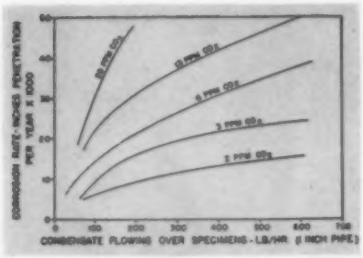

Figure 3—Corrosion rate of CO_2 depends on its concentration and flow rate. Note the drastic rate increase at concentrations above 6 ppm CO_2.

the phenolphthalein and methyl orange alkalinity determinations on the boiler feedwater. In some cases a carbon dioxide concentration as low as 6 ppm may cause a troublesome corrosion problem in the return piping.

However, in addition to the carbon dioxide concentration of the steam, there is one other important consideration in anticipating the severity of corrosion due to carbon dioxide. That consideration is the total pounds of carbon dioxide. Figure 3 clearly illustrates this point. It should be noted that with a carbon dioxide concentration of 6 ppm or above, the rate of corrosion increases rapidly as the rate of flow increases. Another factor which can materially influence the severity of carbon dioxide attack is the possibility of stratification. This leads to a higher rate of attack than expected for the particular flow rate and concentration of carbon dioxide.

Since the carbon dioxide contamination results from an actual breakdown of the carbonate and bicarbonate alkalinity of the feedwater, deaerating practices will be ineffective in reducing the corrosion potential due to this gas. Effective reduction of the corrosion potential may be achieved by external treatment of the feedwater or makeup water to reduce the bicarbonate alkalinity thereof. Such external treating facilities include lime-soda, and lime-gypsum softening, which ordinarily reduce the alkalinity to the 50-60 ppm range. It is advisable, from the standpoint of reducing carbon dioxide corrosion to maintain the softener effluent alkalinity in the carbon-hydrate form, rather than in the form of bicarbonate-carbonate. Other external methods that can be employed to reduce bicarbonate alkalinity to a very low level include acid feed, hydrogen zeolite softening, and dealkalization.

Neutralizing and Filming Amines

When external softening cannot produce a sufficiently low carbon dioxide concentration of the steam, or when the expense for such external treating facilities is not justified, excellent protection from attack can be achieved with the use of neutralizing amines or filming amines.

Neutralization of carbon dioxide can be safely accomplished by certain volatile amines. These amines, when fed to a boiler, volatilize with the steam and combine with the carbon dioxide to neutralize its acidity. Since they react directly with carbon dioxide, the quantity required is proportional to the carbon dioxide content of the steam. Where large amounts of carbon dioxide are present, costs can become excessive.

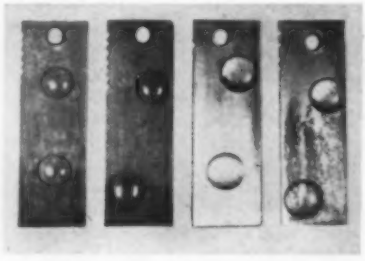

Figure 4—Non-wettability of amine film.

The filming amines function by laying a non-wettable film of monomolecular thickness over the metal surfaces, which is impervious to water. Since the film prevents the water from reaching the metal surface, attack is prevented. The quantity required is independent of the carbon dioxide concentration, and therefore is a more economical treatment particularly where high concentrations of this gas are present. The film forming amines are also effective when oxygen is present in moderate amounts. Figure 4 illustrates the water repellency of the amine film.

Summary

1. Oxygen and carbon dioxide are the chief causes of return line corrosion.
2. Attack by dissolved oxygen is characterized by pits and build-up of deposits of iron oxides.
3. Attack by carbon dioxide is characterized by grooving and actual thinning of the metal pipe walls.
4. Combined attack by oxygen and carbon dioxide will have the characteristics of each.
5. Oxygen attack can be stifled by efficient chemical and mechanical deaeration.
6. Carbon dioxide attack can be inhibited by external reduction of alkalinity and/or use of filming or neutralizing amines.

NEED NOT BE A PROBLEM

A number of factors must be considered on an *individual plant basis* to determine the best way to overcome a return line corrosion problem. Continuing research and development by BETZ LABORATORIES on this important subject has led to a better understanding of the effect of different variables, as well as provided increasingly effective control methods. A BETZ Field Engineer will be happy to discuss your return line corrosion problem and suggest result-producing ways to overcome it. Why not take steps tc call him in *now* while you're thinking about it?

BETZ LABORATORIES, INC.

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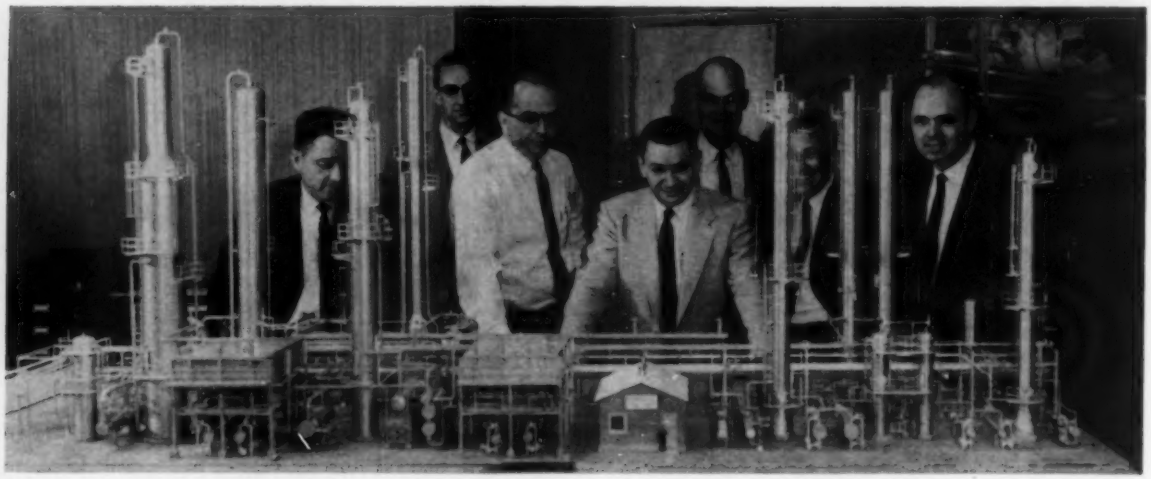
CONSULTANTS ON INDUSTRIAL WATER PROBLEMS



Reviewing the completed model of the Laverne gasoline plant are, from the left: J. P. Hendrix, Plant Superintendent; Bob Bradley, District Manager for J. F. Pritchard & Co.; B. L. Short, Project Engineer, Sun Oil Company; Bill Gains, Project Engineer, J. F. Pritchard & Co.; John Walke, Assistant Manager Gas & Gasoline Dept.; John Shimer, Jr., District Gas Superintendent; and Bill Lawler, Gas Engineer.

Sun Oil Company's Laverne, Oklahoma Plant

What Makes This Plant Different?

B. L. Short, *Project Engineer, Sun Oil Company*

A NEW NATURAL gasoline plant has been built at Laverne, Oklahoma near the western edge of Harper County. It is not a really different type of gasoline plant, but it is a different plant. While the plant is not unique in all its features, it does have some new design features plus the modification or reapplication of many tried and proven features, which overall make it stand out as a new and different plant. These standout design features are:

1. Gas fired turbines driving electrical generators.
2. A direct fired process heater takes its combustion air from the exhaust of the gas turbines.
3. A central control and instrument center.
4. A split deethanizer and reabsorber.
5. No internal combustion engines in the process scheme or in the utilities system except as stand-by.
6. All outside lighting is by mercury vapor lights.
7. All truck loading is by weight and LPG blending is automatically handled.
8. A fire fighting system designed for operation by a minimum number of personnel.
9. A hydraulic turbine is powered by the expanding rich oil from the main absorber.
10. Use of adsorption beds to control the hydrocarbon dew point.
11. Quality control within the plant is maintained by use of a chromatograph.
12. A scaled model of the plant was constructed to speed engineering and construction.

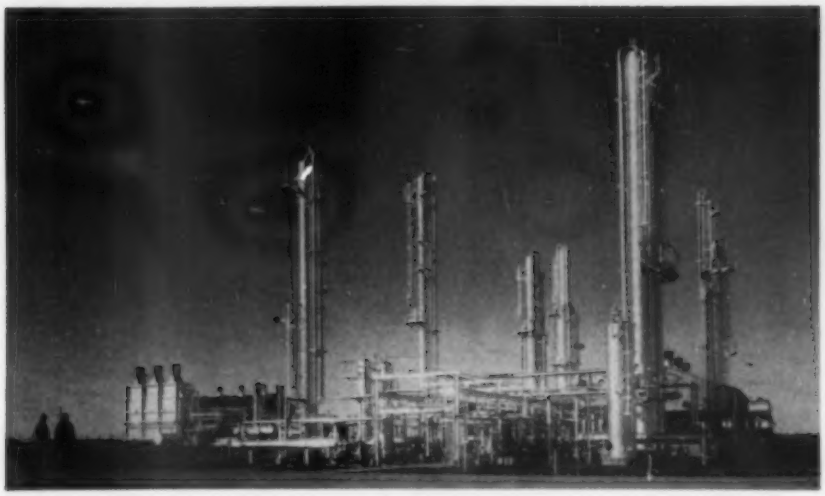
GAS-FIRED TURBINES AND PROCESS HEATER

All pumps and compressors are driven by electric motors except for two stand-by services. This means that the entire plant depends upon the operation of the generator plant. The generators are three 1000-kw, 2400-v, 1200 rpm units driven by gas turbines whose outputs vary with ambient conditions. The plant is designed so that one generator is a spare.

The turbines have one feature that is radically different from reciprocating engine-driven generators — there is no waiting period between starting the driver and putting the generator on the board. There is no cooling water or oil that must come up to temperature before load can be applied. A time of five minutes from preparing to start a turbine until the generator is on the line is on the conservative side, especially for placing the first unit on the line.

The exhaust gases of each turbine are ducted directly to a specially designed direct fired heater. The ducting is also specially designed for this installation. The exhaust gas from each turbine is divided so that a portion of the hot exhaust goes into the fire box of the heater while the remainder enters the heater in the convection section. The duct connecting the center turbine to the heater has a deflector plate at the heater entry to help distribute the hot exhaust gas when either of the two outer turbines is down. The design pressure drop from the turbine exhaust flanges to the heater stack is 2 inches of water. Actual operation has shown that the drop is less than design.

DISCUSSION INVITED . . . the authors of papers appreciate comments and discussion from the readers. Please address your replies . . . for publication or to be directed to the authors . . . to **J. C. Webb, Editor, P. O. Box 1589, Dallas 21, Texas.**



Overall view of the Laverne Gasoline Plant operated by Sun Oil Co.

The exhaust gas from the turbines, at a design temperature of 890 F, consists of approximately 97 percent air, the remainder being the products of complete combustion of turbine fuel gas. The portion of this exhaust gas that enters the fire box of the heater is mixed with the necessary additional fuel gas at the burners and refired. The remainder of the turbine exhaust gas that enters the convection section of the heater merely exchanges its heat with the process streams. The heater stack design temperature is 280 F. The resulting design thermal efficiency compares favorably with the similar installation of a conventional direct fired heater and reciprocating engine-driven generators.

The heater actually has four separate streams fed to it — the lean oil still bottoms, the plant heating oil, the deisobutanizer bottoms (for reboiling) and a regeneration gas stream. All of the heater coils, with the exception of the regeneration gas coil, are carbon steel. The gas coil, since it sees intermittent operation, is fabricated of alloy pipe.

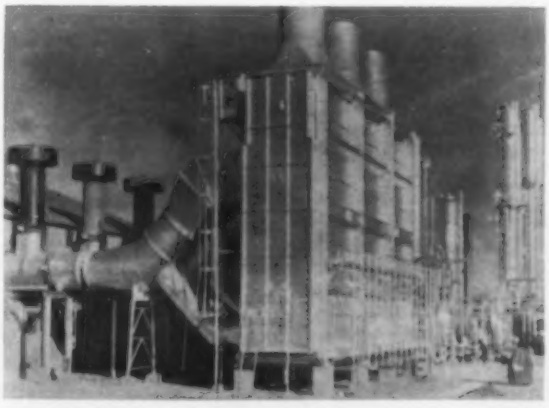
The heater burners receive only air from the turbines — the firebox and burners are completely enclosed. Each burner has an individual electric igniter.

INSTRUMENTATION AND CONTROL

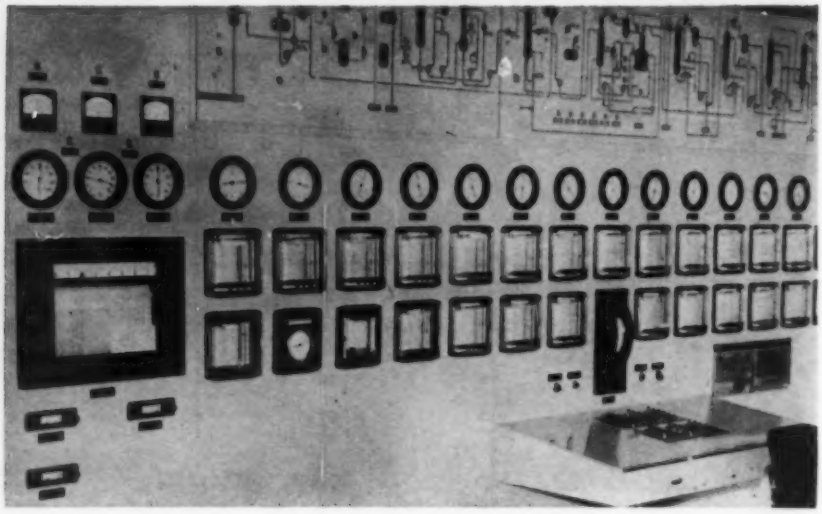
The entire plant design and layout was approached with the basic premise that the plant must be such that it could be operated with a minimum of operating personnel. This led to locating all critical instruments and controls in a central location so that the operator could check the operation of the entire plant in a very short time without the necessity of making a time consuming tour of the entire plant. In addition, the operator can make necessary process corrections from the same central location. All process information critical to the operation of the plant — levels, flows, temperatures and pressures — is brought into a control board located in the center of the process area. This board is a semi-graphic type panel which has a graphic process flow sheet located at the top of the board above the instruments and indicators. All instruments used are miniatures except for two multi-point temperature instruments. The graphic section of the board has alarm lights located at the proper points in the flow sheet to indicate whether operation is normal or not. The instruments are pneumatic instruments except for a few indicating electrical instruments.

Since the design concept called for the operator to have a picture of the entire plant operation before him at all times, the generator plant posed a potential problem. Recognizing the impracticability of using anything other than a conventional generator plant layout — that is, generators and main buss board in a location convenient to each other — planning proceeded along the lines of fitting such a generator plant layout into the original scheme of central control and observation. The main generator board and turbine-driven generators were designed so that the generating operation is self-contained and as near to self-adjusting as is feasible. Once an operator starts a turbine and places the generator on the line, the generator plant requires nothing more than a routine check when the operator makes his rounds. The most critical indicator of the operation of the generator plant — electrical load or kilowatts — can be observed in the central control room on the panel board. Each generator has its own kilowatt meter on this board.

The safety shutdown system for the plant is in reality two systems called *"the Emergency Shutdown System"* and *"the Crash Shutdown System."* The Emergency Shutdown System shuts down just the process portion of the plant, but leaves the remainder of the plant operating so that a temporary condition will not cause complete loss of all utilities. The Crash Shutdown System, as its name implies, shuts everything down. Each system has its own separate actuating system which consists of six shutdown stations



Process heaters, showing the specially design duct conveying the gas fired turbine exhaust gases. Note the gas is divided between the fire box and the convection section of the heaters.



Overall view of the plant's semi-graphic panel and control console.

strategically located throughout the plant area, including one in the central control room and one in the storm cellar.

The Emergency Shutdown System, when actuated, shuts down all process pumps and drivers except the hot oil and still reflux pumps. The cooling water circulating pumps also continue to operate while the gas engine-driven fire water pump is automatically started. Also the main process gas stream is blocked out of the plant.

The Crash Shutdown System simply finishes the shutdown of the complete plant by closing off the main fuel regulator, thus shutting down the generator plant. Since the only non-electric motor-driven units in the plant are one fire water pump and an emergency lighting generator, this effectively shuts in the plant except that the fire fighting system can be operated.

Of course, individual items of equipment have their own safety devices, such as electrical overload relays in the motor controllers, high temperature and low flow shutdowns on the process heater and various safety shutdowns on the turbines, but these operate to protect only the individual unit specified.

DEETHANIZER AND REABSORBER

The deethanizer is actually only the stripping section of a deethanizer and contains 20 trays. Feed enters on the top tray of the deethanizer and ethane and lighter components are removed. The overhead vapor from the deethanizer flows to the reabsorber vessel which is really three vessels in one — a rich oil flash tank, a reabsorber and a preabsorber or presaturator. The deethanizer vapor enters the reabsorber section of this column. The rich oil from the absorber flows to the bottom section of this same vessel where it is flashed, the vapors rising into the reabsorber section and the liquid mixing with the rich oil coming down from the reabsorber section. This liquid stream is the feed to the deethanizer.

The vapors rising through the reabsorber section are contacted by the presaturated lean oil. The lean oil is presaturated in the top section of the reabsorber column by the reabsorber overhead vapors. The presaturated lean oil is divided into two streams, one going to the reabsorber and one to the main absorber. The presaturation operation results in a smaller refrigeration requirement and lower recompressor horsepower requirement.

The deethanizer has two reboilers, one conventionally located in the bottom and one approximately half way up the column. The reboilers actually use waste heat from the lean oil system thus helping increase the thermal efficiency of the plant.

NO INTERNAL COMBUSTION ENGINES

As mentioned previously, there are two internal combustion engines in the entire plant proper plus one on a water well pump. The emergency lighting generator is a small 5-kw generator which furnishes power for emergency lights should the main generators fail at night. This small generator also supplies power for recharging the turbine starting batteries should this ever become necessary.

The fire water pump is driven by a dual fuel, gasoline-natural gas, engine. Even this unit has an electric motor-driven spare.

In the process portion of the plant every pump and compressor is powered by an electric motor. The two recompressor and refrigeration compressor units are driven by 500-hp explosion proof motors, while there are two 200-hp and two 150-hp motor driving lean oil pumps. The remainder of the motors are 100-hp or smaller in size. The extensive use of electric motors presented several problems.

First, how would this fit in with the proposed concept of designing for minimum operating personnel? It was quickly apparent that, on the surface, at least electric motors should be more reliable as far as operating time and maintenance time are concerned. This is especially true for the smaller motors, 100 hp and under. It was determined that all motors over 100 hp should be 2400-v motors (the generated voltage), and all other would be 440 v. With six motors larger than 100 hp, it could be seen that possibilities existed for causing radical voltage and frequency dips should the load shifts occur too radically or not be anticipated. Bear in mind that the actual ability of the turbines to handle these shifts, without additional design features being incorporated in the installation, was still in question. However, it was finally decided that the motors could be started using "across the line" starting equipment.

Next the reverse of this situation was considered. What if a large motor or motors dropped off the line? Would the turbines overspeed? This was something only actual operation could determine.

Another problem along this line was the operation of the plant should one turbine shut down leaving only one generator on the line. Something had to be done about dropping load. The original installation had a relay system that dropped all 2400-v motors should one of the turbines

fall off the line. After a few months operation, it was decided that only the two largest motors need to be dropped in case of turbine failure. This change is now being made.

Actual operation of the plant, even under extreme conditions during testing of the turbines, has been adequate in regard to load shifting.

MERCURY VAPOR LIGHTING

The only incandescent lighting on the plant site is located in the various buildings. All outside lights are 1000-w mercury vapor lights supplied at 480 v. The fixtures are mounted on 50-ft poles located so as to bathe the proper areas in light. The use of this type of lighting exclusively for all area lighting is thought to be a first in gasoline plants.

The biggest problem in the use of these lights has been the radical difference in light and effects as compared to incandescent lights. The mercury vapor lights give an entirely different type and intensity of light. However, there is more actual light available in this plant than was considered possible in the preliminary design stages.

The use of a 480-v lighting system meant no lighting transformers were necessary for area lighting as well as the fact that smaller electrical cable could be used.

The outstanding feature of this plant at night is that it does very definitely stand out as a well lighted plant.

PRODUCT LOADING

All truck loading is by weight. There is no argument about tank capacities, tank tables, gages or such. As a truck enters the plant, the driver pulls onto the scales next to the plant office where he is weighed empty. The truck is then filled at the loading dock and reweighed. The difference in weights is the actual product loaded, which can be converted to liquid gallons.

All LPG blends loaded are blended in the line automatically during loading. Separate propane and butane loading pumps pump the products through a proportioning type controller which can be set for the blend wanted. This controller automatically controls and proportions the amounts of each product so that the desired product is loaded into the truck or tank car.

Bobby L. Short, Dallas, senior gas engineer for Sun Oil Company, was liaison man between Sun and J. F. Pritchard & Company for design and construction of the Laverne (Oklahoma) Gas Products Plant. A native of Tulsa, he joined Sun's gas department 11 years ago upon graduation with BS in chemical engineering from Texas A & M College. He is married and the father of four children.

FIRE FIGHTING SYSTEM

Since the rest of the plant was designed to operate with a minimum of personnel, the safety features of the plant also were designed in keeping with this concept. Chemical extinguishers are located throughout the plant in places calculated to make an extinguisher available to an operator in the shortest possible time. The fire water system covers the entire plant yard and can be separated into two separate systems should trouble occur in one section. There are two fire water pumps, one engine-driven and one electric motor driven. The engine-driven pump is automatically started when the Emergency Shutdown System is activated.

Located at six spots around the Process Area are monitor fire nozzles that can be set to direct water on any part of the Process Area. These nozzles can be adjusted for a direct stream of water or a fog spray of water. In case of fire, these nozzles can be operated as manned stations or they can be set to direct water on a fire or threatened area and left unattended, thus freeing all personnel for other duties in an emergency.

The entire product storage area is covered by a spray nozzle system. Alongside each storage tank is a header on which are mounted spray nozzles spaced at 10-ft intervals. Since the natural gasoline, propane and butane tanks are located in separate clusters, each spray system for each cluster of tanks is separately controlled. The spray system can be operated in the same manner as the monitor nozzles in the process area in that the system can be turned on and left unattended. The nozzles are mounted at a height which will allow the water spray to completely blanket the tanks and help cool them in case of fire.

In addition, the fire water system also has eight conventional fire plugs to be used with fire hose which is stationed near each plug.

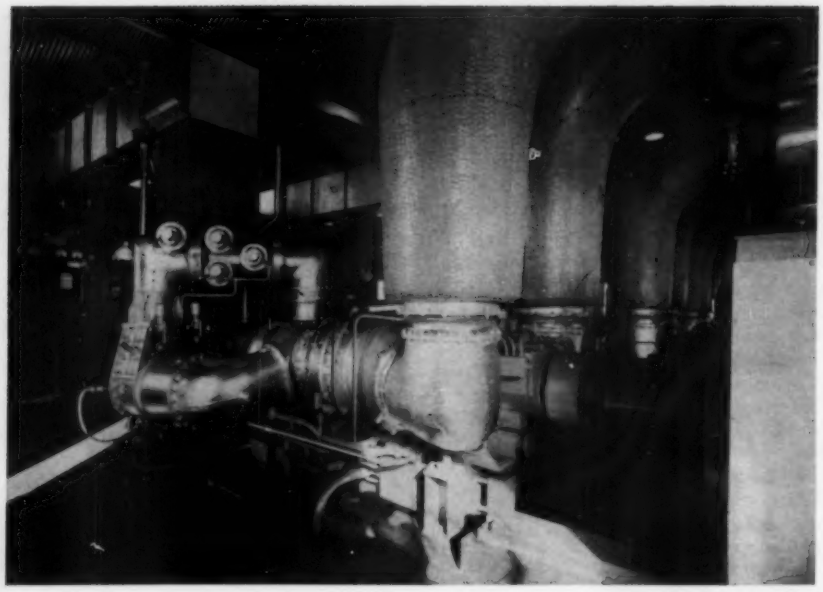
HYDRAULIC TURBINE

The lean oil to the main absorber is pumped by three pumps. Two of the pumps are driven by electric motors, one by a hydraulic turbine which gets its power from the expanding rich oil leaving the main absorber. Any two of the pumps can supply the design oil flow to the absorber. The turbine-driven pump pumps against the absorber pressure while the motor-driven pump pumps against a pressure set by a flow controller on the lean oil line to the absorber. The hydraulic turbine is controlled by a speed controller which allows the pump to operate at a constant point. A by-pass control valve allows rich oil to by-pass the turbine when more rich oil is available than can be used by the turbine. The turbine is designed to recover 180 hp from the expanding rich oil.

HYDROCARBON DEW POINT CONTROL UNITS

The contract under which the raw gas is processed calls for a maximum hydrocarbon dew point of 20 F. This temperature makes it imperative to eliminate any possible carryover of lean oil or other hydrocarbon (propane and heavier) either as free liquid or as equilibrium vapor. High efficiency mist eliminators are installed in the top of the main absorber and presaturator. However, even these will not guarantee the required dew point. Two possible solutions to this problem were (1) the use of refrigeration to condense any hydrocarbon vapors that would raise the outlet dew point or, (2) the use of adsorption beds to accomplish the same purpose. Since the first solution would require an increase in refrigeration requirements with a resulting increase in fuel and operating costs, the installation of the "dry bed" units was considered the most favorable.

Two vertical vessels filled with silica gel and activated charcoal are located downstream of the residue gas separator. One vessel is in service removing hydrocarbon condensables while the other vessel is being regenerated.



Overall view of one of three gas fired turbines at the Laverne plant.

Regeneration is accomplished by using the recompressed gas from the presaturator and reabsorber. This gas is heated in a coil located in the convection section of the process heater. During the cooling period, the gas is simply bypassed around the heater. The operation of these two vessels is designed for automatic control.

CHROMATOGRAPH INSTALLATION

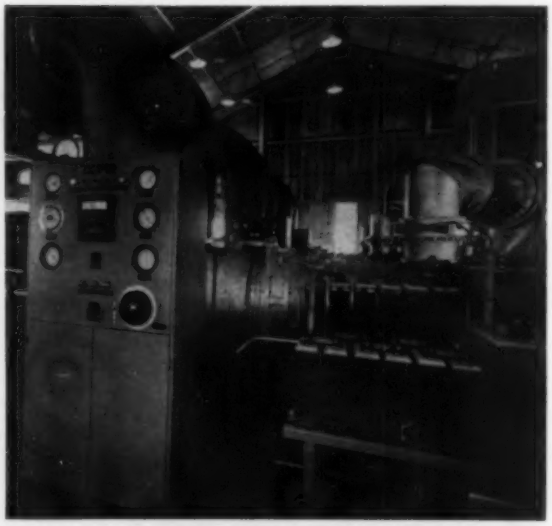
The inclusion of a butane splitter in the fractionation train meant some means of checking quality control other than the standard "boil aways" was essential to plant operation. From previous experience using the two most common types of analytical instruments designed for this purpose, it was decided that the installation of a chromatograph would afford the plant operators a much more useful and flexible tool for checking quality control and plant performance. The chromatograph was installed on the central control board so that the operator can keep a close check on product quality. In addition the operator can check actual performance of the process in removing the recoverable hydrocarbons from the raw gas.

Since the chromatograph was not available during the plant start-up, a direct comparison of operations with and without the instrument has pointed up the usefulness of such equipment.

SCALED MODEL

The installation schedule for the plant dictated that every possible means to speed the job be employed. The use of a scale model was considered to have the following advantages:

- It would speed layout and arrangement of equipment.
- It would help eliminate most errors in piping that usually slow down field construction.
- The use of a model could result in actual savings in piping materials.
- The use of a model could speed up the preparation and release the construction drawings.
- The use of a model, both in the design stage and in the construction stage, would serve to clarify the actual installation desired.
- The model would serve as an excellent tool in training the operating personnel prior to start-up.



Gas turbine installation showing the control panel and d-c batteries used for start-up.

The model was constructed in the contractor's office where constant use of it was made by all design personnel. After the design was fixed and the major part of the piping drawings complete, the model was shipped to the job site where it was used by the field construction forces as well as the plant operators.

ACKNOWLEDGMENT

The features pointed out in this paper are the result of the cooperation of many people. Particular credit should go to **John Walke,** under whose supervision the plant was installed, **W. T. Lawler, H. O. Evinger, J. P. Hendrix, J. M. Shimer, Jr.,** all of Sun Oil Company; **The J. F. Pritchard & Company,** who engineered and constructed the plant, and **W. Gains,** project engineer for the Pritchard organization. In helping to make a practical reality of many of these design ideas, credit is also due the many suppliers who offered their assistance and suggestions. ★ ★ ★

Synthetic fibers . . .

Important Petrochemical Outlets

Michael B. Boylan
Marketing Research Division
Continental Oil Company, Houston, Texas

STABILIZATION OF THE RATE OF GROWTH in demand for fuels and lubricants is leading refiners to direct increasing attention to petroleum derived chemicals as vehicles for growth. Such petrochemicals, either basic raw materials or intermediates, have a dynamic future derived from the almost unlimited growth prospects for synthetic materials which can perform new tasks or which are better or cheaper substitutes for existing natural substances.

Wholly synthetic fibers, for example, have grown since 1940 into a $2.1 billion industry with shipments of 491 million lb of products in 1958. A major synthetic fiber producer has predicted that sometime in the early 1960's, shipments will pass 1 billion lb. Petroleum refiners have supplied most of the basic raw materials and some of the intermediates consumed by fiber producers and these materials will probably continue to be attractive areas for oil company investment. Refiners will have to contend with the tendency of the fiber producers, particularly those having refining affiliates, to integrate backward to raw materials.

Synthetic fibers which deserve the closest attention may be classified into three groups: **Polyamides** (nylon, including nylon 6); **acrylics** (homo- and co-polymers of acrylonitrile); and **polyesters.** These three groups accounted for almost 95 percent of 1958 synthetic fiber shipments and this share should be maintained.

Polyamides

The most important fiber in this group is nylon 66, produced since 1939 by Du Pont and since 1953 by Chemstrand. Shipments of nylon 66 fiber in 1958 totaled about 275 million lb. Much smaller quantities were shipped in resin form for fabrication into plastic products. The outlook is for growth in fiber shipments to around 440 million lb by 1965, with large increases in usage in tire cord and carpets. Nylon is the reaction product of adipic acid and hexamethylenediamine. Adipic acid is made by oxidation of cyclohexane, which in turn may be extracted from refinery streams or made by hydrogenation of benzene. The diamine can be made from furfural, from butadiene, or by further processing of adipic acid. All three processes are employed by Du Pont. Chemstrand uses only the all-adipic acid process, under its license from Du Pont, although the other processes may be more economical. Furfural is not as yet synthetically produced, but refiners can and do supply benzene, cyclohexane and butadiene for nylon intermediates. Table 1 gives estimates of the volumes of these raw materials required by fiber producers in 1958 and forecasts for 1965. Figures for hydrogen cyanide (HCN), another important raw material, are also given.

Nylon 6, while chemically similar to nylon 66, is produced by polymerization of caprolactam. Shipments of nylon 6 fiber in 1958 by nine manufacturers probably totaled about 30 million lb. A smaller quantity was shipped as resin for conversion to plastic products. The outlook by 1965 is for an increase in fiber shipments to about 75 million lb, aided by the introduction of nylon 6 in tire cord. All the caprolactam for nylon 6 is presently supplied by a single producer, Allied Chemical Corporation, though Du Pont and one other firm have announced new plants. The Allied Chemical process for caprolactam begins with benzene and proceeds through phenol and cyclohexane. The new producers use other processes and will probably require new supplies of benzene or cyclohexane.

TABLE 1. Consumption of Basic Raw Materials in Synthetic Fiber Production.
(million pounds)

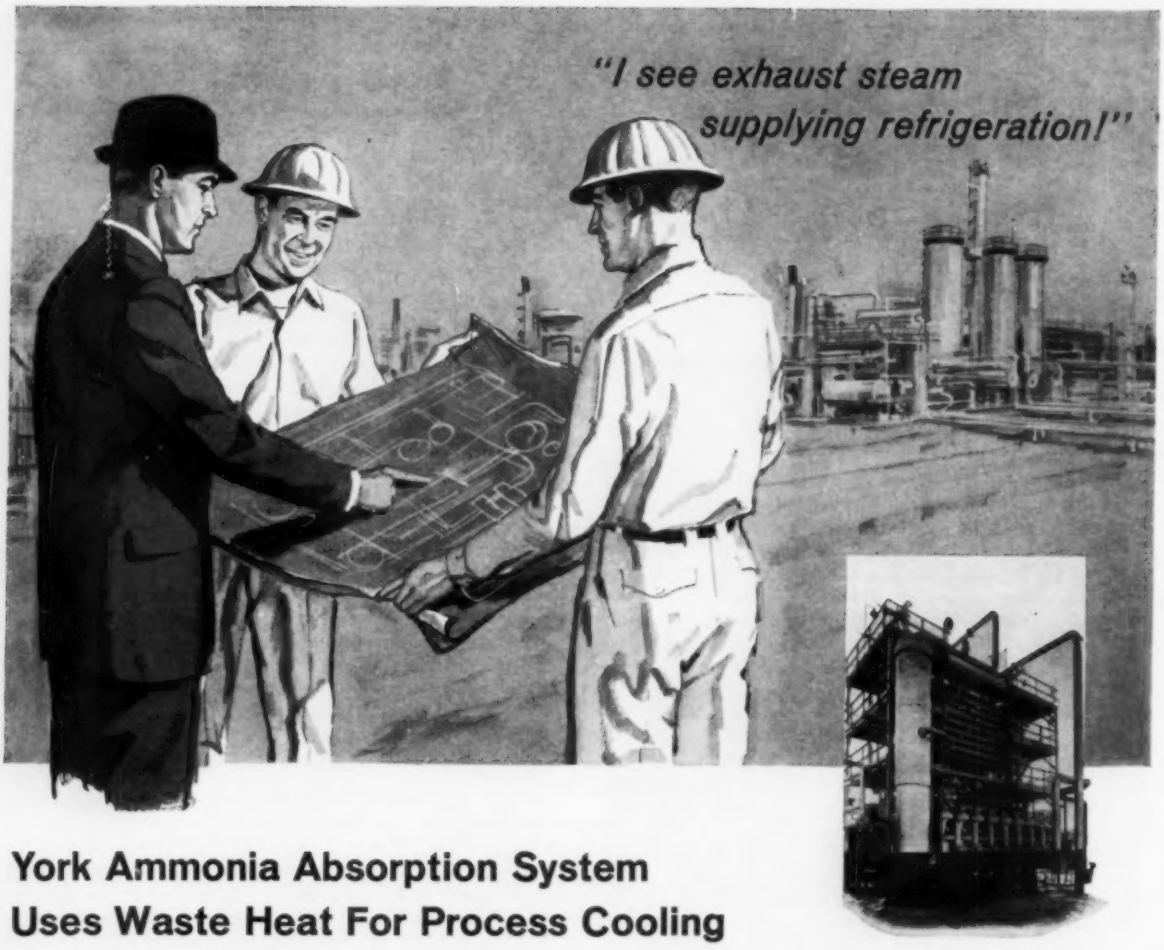
	1958		1965	
	Fiber Production	Raw Mat'l Requirements	Fiber Production	Raw Mat'l Requirements
Polyamides—Nylon 66	275		440	
Butadiene		60		75
Furfural		60		105
Cyclohexane or Benzene		310		450
HCN		69		110
—Nylon 6	30		75	
Benzene		30		45
Cyclohexane or Benzene		—		36
Ammonia		60		150
Acrylics	110		345	
Acrylonitrile		100		320
Polyesters	60		120	
Paraxylene		54		108
Ethylene Glycol		20		40

Acrylics

The acrylic fibers, currently produced in large volume by Du Pont and Chemstrand and on a smaller scale by Cyanamid, Dow, Eastman and Union Carbide, are expected to display the most dynamic growth of any fiber group. Although industrial uses are small, the excellent properties of these fibers, notably those related to comfort and processability, are gaining them widening markets in apparel and household uses. Considerable effort is being directed at tailoring acrylic fibers for specific applications. The outlook is for shipments of these fibers to increase from 110 million lb in 1958 to about 345 million lb in 1965. On the other hand, the principal chemical intermediate, acrylonitrile, can be readily manufactured captively by the chemical and fiber companies. The latter may require moderate quantities of the basic raw materials, ethylene oxide, ammonia and acetylene, but the opportunities for refiners to benefit from the growth of acrylic fibers do not appear large.

Polyesters

The most important polyester fiber is the condensation product of dimethyl terephthalate and ethylene glycol. For many years, Du Pont's Dacron fiber had the field to itself. Eastman, Beaunit and Fiber Industries are new entries. Polyester fiber shipments are expected to grow from about 60 million lb in 1958 to about 120 million lb in 1965. The fiber has growing uses in blends with cotton and wool because it imparts desirable ease-of-care properties. Additional moderate quantities of polyester are consumed as film. The ethylene glycol intermediate is more often made by chemical companies than oil refiners. Although refiners might integrate forward from ethylene to ethylene oxide and glycol, end uses for the products in addition to synthetic fibers would have to be considered. The terephthalate intermediate is made from paraxylene extracted from petroleum streams. Paraxylene thus deserves refiners' attention, although economical methods of disposal of the other xylene isomers would have to be found. ★ ★ ★



York Ammonia Absorption System Uses Waste Heat For Process Cooling

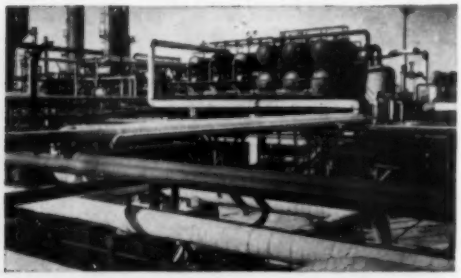
—Can operate unattended for long periods

VERY ECONOMICAL OPERATION—Utilizes exhaust steam from steam turbine driven equipment, hot oil, stack gases or waste heat from any source to provide refrigeration. Also can be direct-fired, if desired. York absorption units save substantially over conventional motor-driven compressor systems.

COMPLETELY AUTOMATIC—A few simple instruments control the system. These need no adjustment and are easily operated by average personnel. Flexible system operates from 100% to 0% capacity with almost constant efficiency, and is unaffected by sudden load changes and refrigerant "slop-over."

VIRTUALLY MAINTENANCE-FREE—Aqua ammonia pump is the only moving component in the entire system. This assures quiet, vibration-free operation and lowest possible maintenance. An extra aqua ammonia pump "spares" the system very economically and eliminates profit-cutting down-time.

INSTALLS OUTDOORS—Rugged construction eliminates need and expense of a building enclosure. Ideal for petro-chemical processing situations, or where indoor space is limited. Also adaptable for ammonia recovery. Capacities from 50 to 5,000 tons refrigeration for temperatures down to −90°F.



Another YORK Trail Blazer Concept Proved in Action at *Cities Service, Lake Charles, La.*—York Ammonia Absorption System uses waste heat from process vapors to deliver economical cooling at this Butadiene plant. Two-stage system provides 3,350 tons capacity—1,133 tons at 45° F. to cool spheroids and 2,217 tons at −5° F. for lean solvent cooling.

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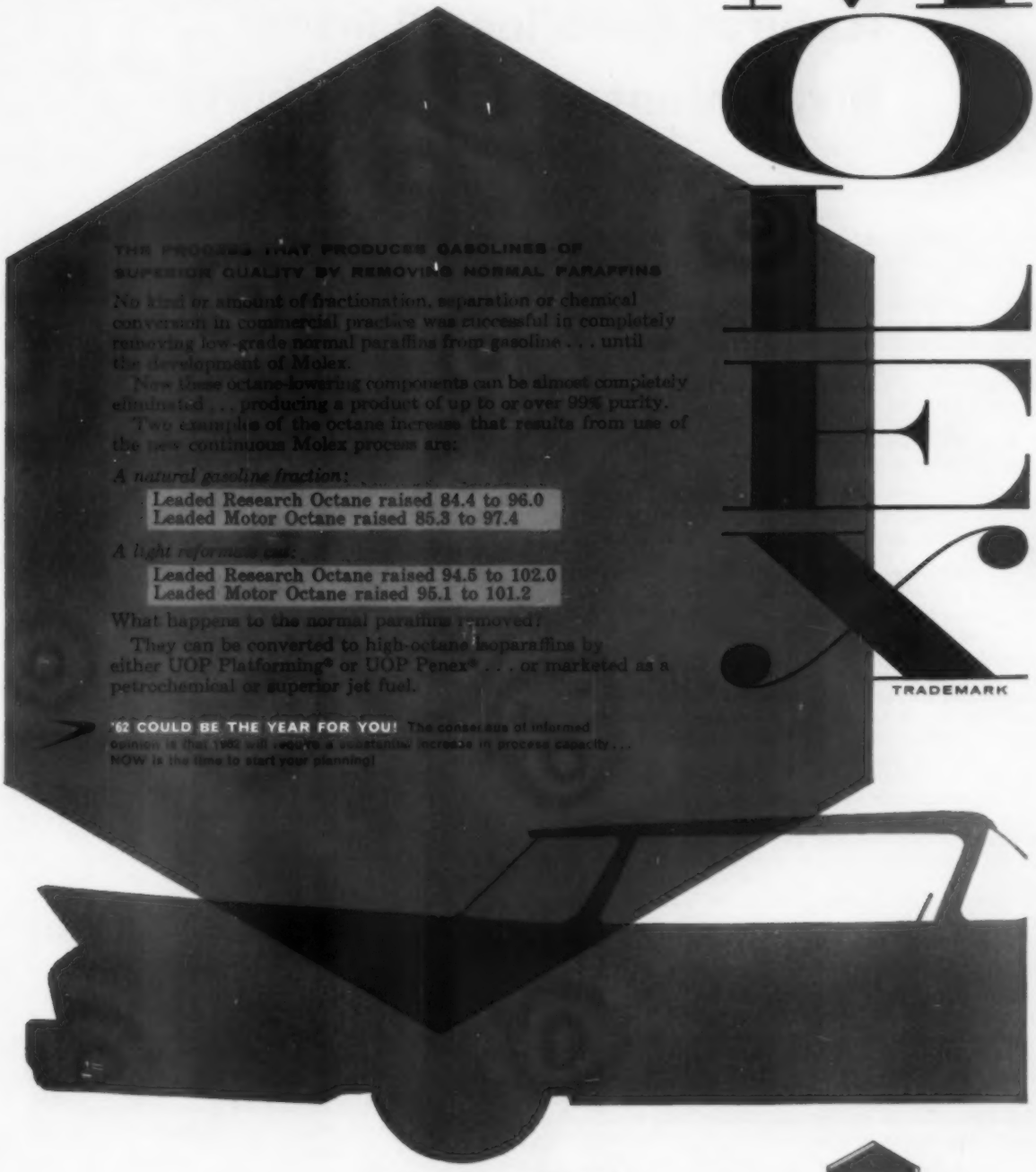
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Natural Gasoline Plant Investment and Profitability

Wayne A. Fling, Jr., *Chief Computer Engineer, Cities Service Oil Co. (Del.)*

PLANT INVESTMENT AND PROFITABILITY OF A NATURAL GASOLINE PLANT frequently require laborious and time consuming calculations. Some projects require calculation of a large number of incremental earnings analyses to compare the many variables of product prices, process selection, recoveries, tax effect, etc. In order to speed up this type of calculation, a program has been written for a medium size computer. This program has a two-fold purpose:

- A fast, accurate method for "quickie" estimates of possible new plant ventures or plant expansions;
- After preliminary evaluation indicates a worthwhile project, a program to give the necessary information for a more precise detailed investment economics picture.

The program is written to require a minimum of input data but still enough data so that a reasonable evaluation of a project can be obtained. As can be seen from Table 1, the input data required is what would be available to a process engineer if he had to manually calculate a "quickie" estimate. The program routine, however, contains rigorous methods of obtaining investment and expense items generally not available to the process engineer. In the past, the process engineer would use his own experience and such information as was available in accounting and operating records to obtain an answer. With the computer, however, it has been possible to investigate all Cities Service plants with respect to investment, operations and maintenance expense, etc. and correlate this data using standard curve fit techniques. This approach, therefore, built into the program the best experience data available and also has the advantage of continually updating the experience curves for cost escalation.

The block flow diagram, Fig. 1, shows the major portions of the program which will be discussed by blocks.

1. Initialize. All of the input data are read into the computer in 5 by 5 notation. The computer program then punches the input data so that a check on the validity of the input data is available. This punching also forms a portion of the output data for inclusion in the final report as well as a check on any omission of input data. After punching, the input data are put into floating point notation for use in the program.

2. Recovery, shrinkage, and residue gas. The inlet gas analysis is converted to a mole basis and, with the given propane recovery, the recoverable gallons of LPG is calculated. The recovery of the butane plus fraction is determined by use of absorption factor methods. The ethane content of the propane product is determined by vapor pressure and material balance. The shrinkage is calculated by conversion of the products to their gas volume equivalent. This volume is subtracted from the inlet volume along with the process fuel, acid gas, and engine fuel to determine the residue gas volume.

3. Gross revenue. Gross revenue is calculated from the input data for the prices of the residue gas and products.

4. Plant investment. Plant investment is calculated from the machine-determined correlations as mentioned above to

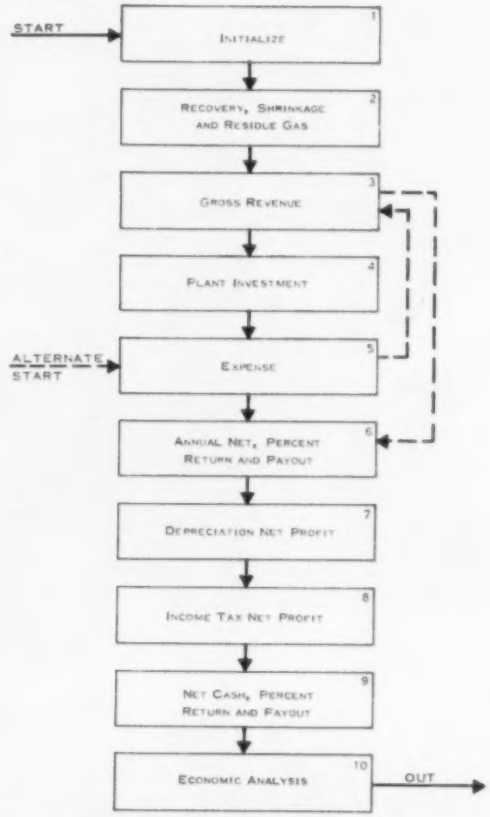

FIG. 1. **Flow diagram** — natural gasoline plant investment and profitability.

DISCUSSION INVITED . . . the authors of papers appreciate comments and discussion from the readers. Please address your replies . . . for publication or to be directed to the authors . . . to **J. C. Webb, Editor, P. O. Box 1589, Dallas 21, Texas.**

determine the cost of the various plant sections (gathering system, absorption, etc.). This investment is a direct function of gas volume and production.

5. Expense. Expense (operation and maintenance) is calculated also from the machine-determined correlations to give the expected cost of operating a new plant from correlations based on past experience. Expense with respect to liquid and gas payments depends on the contract prices necessary to purchase the gas from the producers and, therefore, is calculated from the input data on the gross value of the liquid and gas as predicted from the recovery calculation.

6. Annual net earnings, percent return, and payout. These calculations are simply the subtraction of plant expenses from the gross revenue to give an annual net earnings before taxes and depreciation for the project. The percent return is the annual net earnings divided by the plant investment with the reciprocal being years to payout.

After the more detailed investment economics have been studied from the "quickie" calculations, the program may be re-entered in this section for the final analysis of the project.

7. Depreciation, net profit. Depreciation is determined by the life of the project using the particular depreciation method applicable such as declining balance, straight line, or sum of the years digits. This has the advantage of giving the exact percentage of depreciation to credit the plant for each year of its life. The net profit before taxes then becomes the difference of the annual net and depreciation for each year of plant life.

8. Income tax, net profit. Income tax computation is made according to the tax rate which is to be applied for each particular project. The resulting difference between the net profit before taxes and the income taxes for that year represent the net profit for each year of plant life.

9. Net cash, percent return and payout. Net cash after taxes and before depreciation is calculated for each year of plant life by the addition of net profit and depreciation for each respective year. An overall percent return and payout are figured as mentioned before.

10. Financial return (percent). This calculation is of the iterative type and determines the discount rate which causes the present worth of cash production to equal discounted capital investment. When this has been calculated, the program punches out the answers as shown in Table 2.

If the "quickie" estimate shows that the project under investigation is worthwhile, further analysis is generally undertaken. This consists of making a detailed process selection. The computer is used to do this by the use of other programs, such as absorption, distillation calculation, etc. These programs provide better estimates of plant investment and operating expenses and are used as the necessary input data for the final project analysis. The final analysis may be begun by re-entry into the program as shown on the block diagram.

Plant investment correlations were made by breaking down investment at Cities Service plants into three categories:

(1) Gathering system outside the plant fence,

(2) Plant compression facilities,

(3) Absorption and distillation facilities.

These data were obtained from available accounting ledgers.

Gathering systems were broken down into an analysis by plants of the number of wells, the design gas volume of the gathering system, and treating facilities located outside the plant fence. These data were then adjusted for cost escalations since the original construction of each plant. A curve fit program was used to obtain the best equation from the adjusted data by the least squares method. This equation, with its coefficients, is then used in the program for an estimate of the gathering system investment.

TABLE 1. Input for Example.

(1)	Volume — 65,000 Mcf/Day		
(2)	Analysis — Mol %		
	N_2 4.75	iC_4	0.52
	C_1 76.51	nC_4	1.69
	C_2 9.20	iC_5	0.36
	C_3 5.92	nC_5	0.48
		C_6+	0.57
(3)	Propane recovery — 90%		
(4)	Product prices		
	LPG	4¢/gal	
	Debutanized gasoline	6.25¢/gal	
(5)	Number of wells — 200		
(6)	Horsepower requirements — 14,430		
(7)	Cost index correction factor — 1.00		
(8)	Payments for gas being purchased is set by the specific contract price for the particular project under evaluation 20% of liquid value 75% of residue gas value		
(9)	Life of project — 15 years		
(10)	Construction period — 9 months		

TABLE 2. Output for Example.

(1)	Total Production — 181,190 gal/day	
		gal/day
	Propane	99,917
	Isobutane	10,490
	N-butane	34,237
	Debutanized gasoline	36,546
(2)	Residue gas from plant — 52,025 Mcf/day	
(3)	Plant investment — $8,362,072	
(4)	Gross annual revenue — $5,990,685	
(5)	Annual expense — $3,430,102	
(6)	Annual net from operation (before taxes and depreciation) — $2,560,584	
(7)	Annual percent return (before taxes and depreciation) — 30.6%	
(8)	Years to payout — 3.266 years	
(9)	Depreciation* — $829,099	
(10)	Net earnings before income tax — $1,681,992	
(11)	Income tax** — $874,636	
(12)	Net profit — $807,356	
(13)	Net cash production (after taxes and before depreciation) — $1,636,455	
(14)	Annual percent return — 19.6%	
(15)	Years to payout — 5.11 years	
(16)	Financial return — 18.4%	

* Depreciation for this example was done by the sum of years digits method.

** Income tax is figured at 52% of net earnings after depreciation.

Absorption and distillation facilities are handled in the same manner as the gathering system. These facilities are broken down by plants into product fractionators, absorption columns, product treating, residue gas treating, and auxiliary equipment such as heat exchangers, boilers, cooling towers, aerial coolers, heaters, etc. These data were correlated as a function of the design liquids production and gas handling capacity. This equation and its coefficients are then used in the final program for the estimate of process equipment cost.

Plant compressor facilities were analyzed in a like manner, but no reasonable correlation could be found within the range of the group of plants studied. Therefore, it is handled as dollars per horsepower for the investment purpose of this program.

Table 3 lists the range of variables in the plants that were investigated.

TABLE 3.

Number of wells connected	70 to 2400
Gas volume	8 to 400 MMcf/Day
Liquids production	20 to 850 M gals/Day
Propane recovery	30 to 95%
Type of plants	Conventional oil absorption Combination oil absorption and refrigeration Transmission line plants Field plants
Lean oil molecular weight	140 to 180
Product type	Deethanized Propane, butane and natural gasoline Propane, isobutane, normal butane, and natural gasoline
Gas treating facilities	Glycol dehydration Amine sweetening
Acid gas content	5 to 1500 grains H_2S/100 SCF
Geographic locations	Mid Continent USA

The program has the following limitations:

1. It cannot be used on package gasoline plants or plants under or over the ranges as listed in Table 3. Separate correlation data would have to be developed for plants which do not fall in the range of conventional gasoline plants studied.

2. All answers must be thoroughly analyzed for reasonability. Judgment based on experience is a prime requisite in selecting input data and in making use of the program output.

The program at present is being used to evaluate a wide variety of gasoline plant ventures to determine economic feasibility. The alternate start is used to a considerable extent in evaluating proposed plant additions and profitability of budgeted construction projects. Since the program is capable of developing an earnings estimate for individual plants, it is, therefore, adaptable for use in preparation of annual budget forecasts for overall gasoline plant operations. At present, we are working on this phase of the computer program, so as to eliminate a large part of the time-consuming detail required in budget forecasting.

The future potential for gasoline plant economic evaluation programs is very good. With the newer and larger machines, where more program storage and faster calculating time is available, it will be possible to combine the various detailed process design programs with plant economics studies for single pass evaluation of proposed gasoline plant projects.

Wayne A. Fling, Jr., *received his BS degree in chemical engineering from the University of Kansas in 1954. After graduation, he went to work as a process engineer in the Bartlesville, Oklahoma, offices of the Cities Service Oil Company (Del.), Natural Gasoline Division. Since then, he has held the positions of Project Engineer, Operations Superintendent of the Chico Gasoline Plant, and his present position as Chief Computer Engineer. He is a registered professional engineer in Oklahoma and an associate member of the AIChE.*

Acknowledgment

The author wishes to acknowledge the contributions and helpful assistance of George C. Vaughan. He would also like to thank Cities Service Oil Company (Del.) for permission to publish the information in this article. ★ ★ ★

Thermodynamics Conference

Tentative program of the Thermodynamics Conference April 18 and 19 at Oklahoma State University, Stillwater, has been announced by **Dr. R. N. Maddox, P. E.,** head of the School of Chemical Engineering.

Speakers will be . . .

Principal speakers will be **Prof. Wayne C. Edmister, P. E.,** authority in the field of hydrocarbon thermodynamics and process design; **Dr. Daniel R. Stull,** director of the Dow Chemical Company Thermal Laboratory, and **Dr. Y. S. Touloukian,** director of the Purdue University Thermophysical Properties Research Center.

W. C. Edmister

D. R. Stull

Y. S. Touloukian

Subjects to be covered are:

Thermodynamics of the First Order—Fundamentals and recent developments in classical and irreversible thermodynamics.

Heat Measurements—Techniques for laboratory determinations of heat capacities and heats of reactions.

Calculated Thermodynamic Properties — Theory and methods of computing entropy, free energy, etc., of ideal gases and real materials such as liquids and solids.

Applications of Thermodynamics — Uses of measured and calculated thermodynamic properties in solving practical problems, such as heats of chemical reactions, chemical reaction equilibria, rocketing, etc.

Enthalpies and Densities of Hydrocarbon Mixtures — Partial volumes and partial enthalpies of components of vapor and liquid hydrocarbon mixtures, to be discussed from a process engineering viewpoint.

Transport Properties—Theoretical methods of evaluating transport properties of gases and correlation methods for predicting viscosities, thermal conductivities and diffusivities.

Needs for Thermophysical Properties — Summary of work of the Purdue University Thermophysical Properties Research Center in preparing comprehensive compilations of information on transport properties for science and technology.

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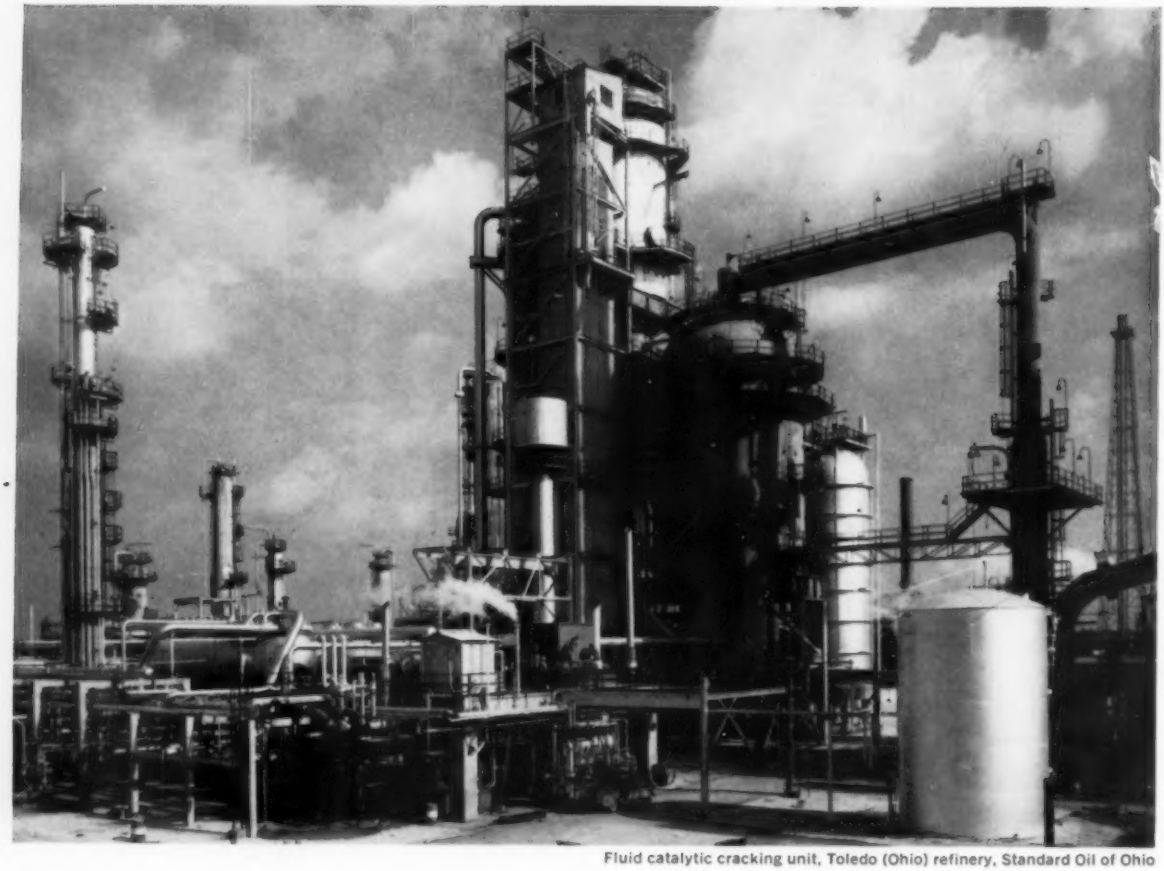

Fluid catalytic cracking unit, Toledo (Ohio) refinery, Standard Oil of Ohio

Refractory insulating concrete stops corrosion in this new FCC

In constructing the fluid catalytic cracking unit at Sohio's new Toledo refinery, corrosion resistance, abrasion resistance and insulation were built in right from the start. Refractory insulating concrete, bonded with LUMNITE calcium-aluminate cement, was used to line the regenerator, cyclones, stripper, catalyst and reactor transfer lines. Now on stream, these industrial concrete linings will resist severe erosion and abrasion caused by catalyst fines... resist attack by acid condensate... and provide insulation at high temperatures.

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Higher extraction efficiencies require...

A DESIGN TECHNIQUE FOR COLD ABSORBERS

C. Shults Faulkner
Ignacio Albiol
Pona Engineers, Inc.

HIGH EXTRACTION EFFICIENCY gasoline plant installations are increasing in the industry today. Overall recoveries of 80 percent of the propane, 95 percent of the total butanes and essentially total recovery of the pentanes and heavier from the raw gas plant feed are fairly typical of modern design.

As a result, oil absorption type plants are utilizing refrigeration to cool certain principal streams, such as raw gas, absorber lean oil, deethanizer reflux systems, etc., to achieve such recoveries.

Unless the gas is unusually rich and/or the desired recoveries lower than the above stated extraction efficiency, an absorber and lean oil system are usually installed to achieve the desired extraction.

Within limits, the overall investment, when an absorption system is used, can be reduced by minimizing lean oil circulation rates, and as a result, the size of downstream oil recovery facilities and the amount of energy input to accommodate such facilities can be reduced.

For a given operating pressure and percent extraction, lowering of the molecular weight of the lean oil and lowering of the absorption temperatures helps to reduce lean oil circulation rates. Also, with other conditions being constant, a lower absorber operating temperature allows the use of lower molecular weight oils for a given lean oil loss. Due to volatility relationships, since the lean oils normally used are predominately paraffinic base oils, the decrease in boiling point with decreasing molecular weight gives the designer a greater flexibility in choosing downstream oil recovery facilities.

This is a technique for estimating the performance of a main stream absorber in which the temperature rise inside the absorber is minimized by use of an external controlled temperature contact between the absorber residue gas and the denuded lean oil. This contact may be accomplished (Fig. 1) by passing the absorber overhead residue gas and lean oil concurrently through a heat exchanger (a refrigerating medium is used on the opposite side to this gas-oil mixture) whereby the mixture is cooled to some lower temperature than the average absorber temperature. From this cooling and contact step, the oil-gas mixture is passed to a flash drum from which the final residue gas is removed overhead and the saturated lean oil is pumped to the top tray of the absorber.

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As a result of this contact step outside of the absorber under controlled conditions, a substantial portion of the heat of absorption can be removed outside the absorber and lower mean absorber temperatures can be obtained. Lower mean absorber temperatures can also be attained by use of refrigerated intercoolers, although the use of some form of the general arrangement in Fig. 1 is solely considered in this discussion.

A process design technique is outlined here to determine lean oil rate and the amount of absorption of the components in the rich gas in such an arrangement and is demonstrated by the use of a sample problem.

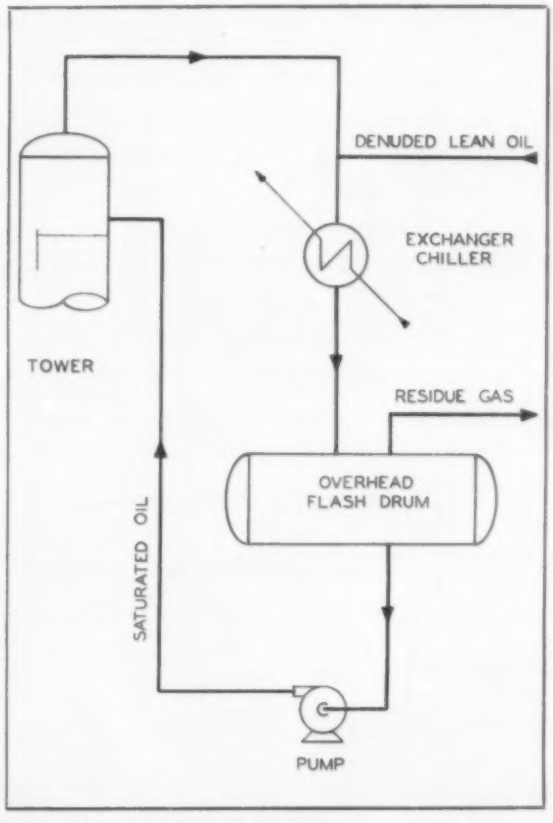

FIG. 1. Schematic absorber system diagram.

DESIGN PROCEDURE

Step 1

Fix the recovery of the desired component.

Step 2

Assume number of theoretical trays inside the absorber. The reader is referred to articles by Kennedy, Chancellor and Rahmes,[1] Williams and Warzel,[2] Hull and Raymond,[3] and Kirkbride and Bertetti,[4] for data and the bibliography given in these articles on absorber tray efficiencies.

Step 3

Assume an average absorption temperature.

Step 4

Assume an average L/V for the absorber.

Step 5

Calculate the absorption Factor, $A = L/VK$ for each component from the L/V assumed in Step 4, K is the component equilibrium constant at system pressure and the average temperature assumed in Step 3.

Step 6

From the Kremser-Brown diagram, read extraction efficiencies for each component from the absorption factors A calculated in Step 5 for the number of theoretical trays.

Step 7

Calculate L_oX_o for the desired component. The derivation of the equation to solve for this term is given as follows: (The reader is referred to Edmister's[5] articles for basic absorption relationships and nomenclature).

V_{n+1} = Mols of rich gas in, per unit time

V_1 = Mols of absorber overhead out, per unit time

L_n = Mols of rich oil out, per unit time

V_o = Mols of residue gas out, per unit time

L_o = Mols of saturated lean oil in, per unit time

Y = Mol fraction of a component in the gas

X = Mol fraction of a component in the liquid

n = Bottom tray

1 = Top tray

o = Flash drum

$$E_a = \left(\frac{A^{n+1} - A}{A^{n+1} - 1}\right)\left(1 - \frac{L_oX_o}{AV_{n+1}Y_{n+1}}\right). \quad . \quad . \quad . \quad . \quad . \quad (1)$$

E_a = Absorber efficiency factor

$$= \frac{\text{amount of a component absorbed inside the absorber}}{\text{amount of a component in the rich gas}}$$

$\left(\frac{A^{n+1} - A}{A^{n+1} - 1}\right)$ = Kremser-Brown extraction efficiency factor

$\left(1 - \frac{L_oX_o}{AV_{n+1}Y_{n+1}}\right)$ = Correction factor for the presence of component in the saturated lean oil

Substituting E′ for $\left(\frac{A^{n+1} - A}{A^{n+1} - 1}\right)$

$$E_a = E'\left(1 - \frac{L_oX_o}{AV_{n+1}Y_{n+1}}\right) \quad . \quad . \quad . \quad (1A)$$

Also by material balances

$$L_nX_n - L_oX_o = V_{n+1}Y_{n+1}E_a \quad . \quad . \quad . \quad (2)$$

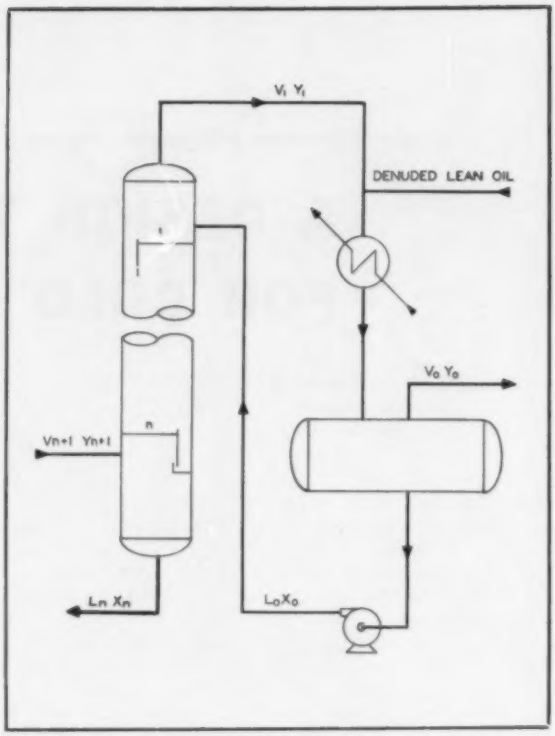

FIG. 2. Arrangement of nomenclature for system calculations.

Where

L_nX_n = Amount of a component in rich oil

L_oX_o = Amount of a component in saturated oil

$V_{n+1}Y_{n+1}$ = Amount of a component in rich gas

Multiply both sides of Equation 1-A by $(V_{n+1}Y_{n+1})$

$$(V_{n+1}Y_{n+1})\,E_a = E'\left(V_{n+1}Y_{n+1} - \frac{L_oX_o}{A}\right). \quad . \quad (3)$$

Therefore, combining Equations 2 and 3

$$L_nX_n - L_oX_o = E'\left(V_{n+1}Y_{n+1} - \frac{L_oX_o}{A}\right) \quad . \quad . \quad (4)$$

Combining Common Factors

$$L_oX_o\left(1 - \frac{E'}{A}\right) = L_nX_n - E'\,(V_{n+1}Y_{n+1}) \quad . \quad (5)$$

And solving for L_oX_o

$$L_oX_o = \frac{L_nX_n - [E'(V_{n+1}Y_{n+1})]}{\left(1 - \frac{E'}{A}\right)} \quad . \quad . \quad . \quad (6)$$

Step 8

Calculate the V/L (for the saturated oil-residue gas flash) from L_oX_o calculated from Equation 6.

For any component except lean oil, a material balance around the system is

$$(V_{n+1}Y_{n+1}) - L_nX_n = V_oX_o \quad . \quad . \quad . \quad (7)$$

By definition, the flash relationship for the overhead flash drum is

$$\frac{KV}{L} = \frac{V_oX_o}{L_oX_o} \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

and

$$\frac{V}{L} = \frac{V_oX_o}{KL_oX_o} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

K = Equilibrium constant of the component at the flash drum conditions

Step 9

Calculate KV/L for the flash drum conditions for all the other components from the V/L given by Equation 9.

Step 10

Calculate L_oX_o for all other components except the true lean oil.

Equation 4 may be rewritten in terms of extraction from the gas as follows:

$$[(V_{n+1}\ Y_{n+1})\ E'] - \left[(L_oX_o)\left(\frac{E'}{A}\right)\right] = (V_{n+1}\ Y_{n+1} - V_1Y_1)$$
$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 10$$

Also since V_1Y_1 is the gas feed to the outside exchanger, then the flash calculations in the overhead drum may be written

$$V_1Y_1 = L_oX_o\left(\frac{KV}{L} + 1\right) \quad . \quad . \quad . \quad . \quad (11)$$

Substituting the left term in Equation 11 into Equation 10, we get

$$[(V_{n+1}Y_{n+1})\ E'] - \left[(L_oX_o)\left(\frac{E'}{A}\right)\right] =$$

$$(V_{n+1}\ Y_{n+1}) - \left[(L_oX_o)\left(\frac{KV}{L} + 1\right)\right] \quad . \quad . \quad (12)$$

Rearranging the terms this can be written

$$L_oX_o = \frac{V_{n+1}Y_{n+1}\ (1 - E')}{\left[\left(\frac{KV}{L} + 1\right) - \left(\frac{E'}{A}\right)\right]} \quad . \quad . \quad . \quad (13)$$

All terms are known on the right side, so L_oX_o can be calculated for each component.

Step 11

Using Equation 11 calculate the amount of the absorbed components in the absorber overhead. Then, by material balance, calculate V_oY_o, the flash drum residue gas composition for absorbed products only, using the relation $L_oX_o - V_1Y_1 = V_oY_o$.

C. Shults Faulkner

Ignacio B. Albiol

C. Shults Faulkner *is president of Pona Engineers, Inc., Houston, which he founded in 1954. Previously he was vice president and chief engineer of McBride Oil and Gas Corporation, chief engineer of Grebe and Doremus Process Co., in process development for Joseph A. Coy Co., and process engineer for West and Cole Construction Co. and Eastern States Petroleum Company. He holds BS in chemical engineering from the University of Texas.*

Ignacio B. Albiol, *process engineer with Pona Engineers, Inc., Houston, since 1957, holds a BS in chemical engineering from the University of Texas. A native of Spain, Albiol also is a graduate of the Industrial School, Tarrasa, Spain, with degree of BA in industrial chemistry.*

Step 12

Calculate L_oX_o for the true lean oil from the known KV/L and the amount of absorbed components in V_o and L_o. Then calculate true lean oil to flash drum. The amount of true lean oil in the residue gas = V_oY_o.

Also from Equation 8

$$V_oY_o = L_oX_o\left(\frac{KV}{L}\right) \quad . \quad . \quad . \quad . \quad (8A)$$

$$\text{Residue Gas, } V_o = (V_o - V_oY_o) + L_oX_o\frac{KV}{L} \quad . \quad . \quad (14)$$

$(V_o - V_oY_o)$ can be calculated from Step 9.

Also, the saturated lean oil, $L_o = (L_o - L_oX_o) + L_oX_o$

$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

$(L_o - L_oX_o)$ can be calculated from Step 10.

By definition $\frac{V}{L} = \frac{V_o}{L_o}$

Then rearranging Equations 14 and 15 we get

$$(V_o - V_oY_o) + L_oX_o\frac{KV}{L} =$$

$$\frac{V}{L}\ [(L_o - L_oX_o + L_oX_o] \quad . \quad . \quad . \quad . \quad (16)$$

Solving for L_oX_o

$$L_oX_o = \left[(V_o - V_oX_o) - \frac{V}{L}(L_o - L_oX_o)\right] \Big/ \left(\frac{V}{L} - \frac{KV}{L}\right)$$
$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

True lean oil to flash drum $= L_oX_o\ K\frac{V}{L} + 1$

(by definition)

Step 13

Calculate $\left(\frac{L}{V}\right)_{avg}$ for the absorber

$$\left(\frac{L}{V}\right)_{avg} = \left(\frac{L_o + \frac{\text{Net Absorption}}{2}}{V_{n+1} - \frac{\text{Net Absorption}}{2}}\right) \quad . \quad . \quad (18)$$

The L/V_{avg} calculated in this step must check the initial assumption made in Step 4, and if a reasonable check is not obtained, the steps must be repeated. In this calculation the amount of true lean oil stripped in the absorber can be approximated from L_oX_o and the average absorption Factor A.

Step 14

Establish the absorber top tray temperature by a dew point calculation and heat balance.

Steps to be taken in this calculation are

A. Assume a top tray temperature,

B. Run a dew point calculation on V_1 filling in the void with lean oil. This gives a composition for the liquid in equilibrium with the overhead vapor.

Since the amount of true lean oil in the saturated lean oil is known, and since the mols of true lean oil are essentially the same as in the liquid leaving the tray, a total volume of liquid leaving the top tray (L_1) can be calculated.

By difference ($L_1 - L_o$) (the amount of stripping or absorption of each component which occurs on the top tray) can be calculated.

Since the temperature of the L_o is known, a heat balance can be made around the top tray to determine the temperature rise across this tray. The value of this rise added to the temperature of L_o should closely check the original assumed top tray temperature. Successive trial and error calculations are required until a check is made.

Step 15

Calculate the rich oil temperature by heat balance around the column.

Step 16

Check the assumed average temperature. It is considered that the absorption of the light components (propane and lighter) takes place principally in the top section of the tower.

TRIAL NO. 1

Propane Recovery 57.5% = 424.4 mols/day, No. of Theoretical Trays = 4.0, Average Temperature = 20 F., Average (L/V) = 0.1038

For Propane: A = 0.59655, E' = 0.5576, Vn+1Yn+1 = 411.2, E'/A = 0.93475, L_oX_o = (424.4 - 411.2) (1-0.93475) = 202.3 mol/day, (KV/L)= 313.1/202.3 = 1.5477
V/L = 1.5477/0.152 = 10.18224

	Rich Gas Vn+1Yn+1 Mols/Day	3000# C.P. 20 F. $K_{700\#\ A}$	A=L/KV	E'	(Vn+1Yn+1)x (1-E') Mols/Day	E'/A	3000# C.P. V/L = 10.18224 F. $K_{700\#\ A}$	(KV/L+1)= (KV/L)+1	(E'/A)	Satur. Lean Oil L_oX_o Mols/Day	Res. Gas V_oX_o Mols/day	Exch.Feed Vn+1Yn+1 + Lean Oil Mols/Day	Absorbed Mols/Day	Stripped Mols/Day	Rich Oil LnXn Mols/Day
CO_2	101.9	0.56	0.1854	0.1854	83.0	1.0	0.52	6.2948	5.2948	15.7	83.7	98.7	3.2	-	18.9
N_2	444.9	12.6	0.00824	0.00824	441.2	1.0	12.2	125.223	124.223	3.6	441.2	444.8	0.1	-	3.7
C_1	17,950.6	3.35	0.03099	0.03099	17,394.4	1.0	3.19	33.4814	32.4814	535.5	17,394.4	17,929.9	20.7	-	556.2
C_2	3,399.8	0.99	0.1759	0.1759	2,801.7	1.0	0.545	6.5493	5.5493	504.9	2,801.7	3,306.6	93.2	-	598.1
C_3	735.5	0.174	0.55955	0.5576	326.3	0.935	0.152	2.5477	1.6127	202.3	313.1	514.4	222.1	-	424.4
iC_4	65.0	0.0745	1.3933	0.9065	6.1	0.651	0.064	1.652	1.001	6.1	3.9	10.0	55.0	-	61.1
nC_4	104.7	0.0546	1.9011	0.959	4.3	0.504	0.0465	1.473	0.969	4.4	2.1	6.5	98.2	-	102.6
iC_5	21.6	0.0238	4.21	1.0						1,272.5	21,039.4		21.6	-	21.6
nC_5	10.1	0.0183	5.67	1.0									10.1	-	10.1
C_6	3.2	0.00675	14.81	1.0									3.2	-	3.2
C_{7+}	0.3	0.00093	111.61	1.0									0.3	-	0.3
LO	-	0.00047	220.85	1.0			0.00036	1.00367		794.1	2.9	797.0	-	3.6	790.2
	22,839.6									2,066.6	21,042.3	23,108.9	527.7	3.6	2,590.4
Lbs/Day	451,029									135,662					159,683
Ave.M.Wt.	19.75									65.65					61.64

Net Absorption = 527.7 - 3.6 = 524.1 mols/day, Then (L/V)ave. = (2066.6 - 262.0)/(22,839.6 - 262.0) = 0.1031 (check assumed value)

Establish the absorber top tray temperature: Assume 21 F.

Component	Absorb. Overh. V_1Y_1 Mols/Day	3000# C.P. 21 F $K_{700\#\ A}$	V_1Y_1 / K	Top Tray Liquid L_1X_1 Mols/Day	Top Tray Liquid-Saturated Lean Oil $(L_1X_1 - L_oX_o)$ Mols/Day	Lbs/Day	ΔH Btu/lb.	Heat of Absorption $(L_1X_1 - L_oX_o)\Delta H$ Btu/Day
CO_2	98.7	0.564	175.0	17.3	1.6	70.4	86.5	6,090
N_2	444.8	12.66	35.1	3.5	-0.1	- 2.8	81.0	- 227
C_1	17,929.9	3.367	5,325.2	535.6	-9.9	-158.4	152.5	-24,156
C_2	3,306.6	0.595	5,557.3	548.5	43.6	1,308.0	137.3	179,588
C_3	515.4	0.176	2,928.4	289.0	86.7	3,814.8	132.0	503,554
iC_4	10.0	0.0756	132.3	13.1	7.0	406.0	125.5	50,953
nC_4	6.5	0.0554	117.3	11.6	7.2	417.6	133.6	55,791
Lean Oil	3.9*	0.000485	8,045.3	794.1				
	22,315.8		22,315.8	2,202.7				771,593

Lbs/day 427,008
Ave. M. Wt. 19.13

Top Section heat of absorption per pound of saturated lean oil = 771,593/135,662 = 5.7 Btu/lb

Heat Capacity of lean oil = 0.52 Btu/lb - °F.

Rise in temperature = 5.7/0.52 = 11 F

Then top tray temperature = 21 F. (checks assumed value)

* Calculated to fill the "void" in lean oil

Estimate the rich oil temperature by heat balance around absorber:

Stream	Temperature, F	Lbs/day	Btu/lb	Heat in, Btu/day	Heat out, Btu/day
Rich Gas	10	451,029	273.5	123,356,400	
Saturated Lean Oil	10	135,662	102.0	13,837,500	
Absorber Overhead	21	427,008	280.0		119,562,200
Rich Oil	T_{RO}	159,683	h_{RO}		17,631,700
				137,193,900	137,193,900

h_{RO} = 17,631,700/159,683 = 110.4 Btu/lb, Then T_{RO} = 24 F.

From the data assembled up to this point in the calculations, the average L/V ratio around the top tray can be determined. From this L/V ratio, an average absorption factor, A_1, can be calculated.

$$A_1 = \frac{\frac{L_o}{2V_1} + \frac{L_1}{2V_2}}{K_{\text{(top tray)}}} \quad \ldots\ldots \quad (19)$$

The value calculated from Equation 19 should closely approximate the A factors at the average temperature originally assumed for the light components. If a reasonable check is not realized, a new average absorption temperature should be chosen.

Also, since it is considered that butanes absorption takes place at near the average absorption temperature, the A calculated from Equation 19 should not be greater than the calculated value at the average absorption temperature originally assumed. Below the top tray absorption factors for butanes will be greater than those calculated around the top tray. Since total or essentially total recovery of pentanes and heavier is obtained, the differences in A_{avg} calculated from Equation 19 and those values calculated at average tower condition have no significance.

EXAMPLE

GIVEN:

Rich Gas In:

Volume	8,656,208 SCFD
Temperature	10 F
Propane extraction desired	57.5%

Lean Oil:

Molecular Weight	128
U.O.P. Characterization Factor	11.8

Exit Temperature of External Contact: 10 F.

Absorber Operating Pressure: 700 psia

Rich Gas Analysis:

	Mols/Day	Mol %
CO_2	101.2	0.44
N_2	444.9	1.95
C_1	17,950.6	78.60
C_2	3,399.8	14.89
C_3	737.5	3.23
iC_4	65.0	0.29
nC_4	104.7	0.46
iC_5	21.6	0.09
NC_5	10.1	0.04
C_6	3.2	0.01
C_{7+}*	0.3	.....
	22,839.6	100.0

*Molecular weight of 114

TRIAL NO. 2

Propane Recovery 57.5% = 424.4 Mols/Day, No. of Theoretical Trays = 4.0, Average Temperature = 25 F, Average (L/V) = 0.110

For Propane: A= 0.5946, E'=0.556, Vn+1Yn+1E'=410.0, E'/A=0.9351, L_oX_o= (424.4÷410.0)(1-0.9351)=221.9 Mols/Day, $\frac{K}{L}$=313.1/221.9=1.411, $\frac{V}{L}$=1.411/0.152=9.2829

	Rich Gas Vn+1Yn+1 Mols/Day	3000#C.P. 25 F K 700# A	A=L/KV	E'	(Vn+1Yn+1)x (1-E') Mols/Day	E'/A	3000#C.P. 10 F K 700#A	V/L = 9.2829 (KV/L)+1	(KV/L+1)- (E'/A)	Satur. Lean Oil L_oX_o Mols/Day	Res.Gas V_oY_o Mols/Day	Exch. Feed Vn+1Yn+1 + Lean Oil Mols/Day	Absorbed Mols/Day	Stripped Mols/Day	Rich Oil LnXn Mols/Day
CO_2	101.9	0.58	0.1896	0.1896	82.6	1.0	0.52	5.8271	5.8271	17.1	82.6	99.7	2.2	-	19.3
N_2	444.9	12.90	0.00853	0.00853	441.1	1.0	12.2	114.251	113.251	3.9	441.1	445.0	-	0.1	3.8
C_1	17,950.6	3.435	0.03202	0.03202	17,375.8	1.0	3.19	30.6124	29.6124	586.8	17,375.8	17,962.6	-	12.0	574.8
C_2	3,399.8	0.616	0.1786	0.1786	2,792.7	1.0	0.545	6.0592	5.0592	552.0	2,792.7	3,344.7	55.1	-	607.1
C_3	737.5	0.185	0.5946	0.556	327.5	0.9351	0.152	2.411	1.4759	221.9	313.1	535.0	202.5	-	424.4
iC_4	65.0	0.0805	1.3665	0.9005	6.5	0.659	0.064	1.594	0.935	7.0	4.1	11.1	53.9	-	60.9
nC_4	104.7	0.0593	1.855	0.956	4.6	0.515	0.0465	1.432	0.917	5.0	2.2	7.2	97.5	-	102.5
iC_5	21.6	0.0262	4.199	1.0						1,393.7	21,011.6		21.6	-	21.6
nC_5	10.1	0.0205	5.366	1.0									10.1	-	10.1
C_6	3.2	0.0076	14.474	1.0									3.2	-	3.2
C_{7+}	0.3	0.00109	100.92	1.0									0.3	-	0.3
Lo	-	0.00054	201.83	1.0			0.00036	1.00334		870.1	2.9	873.0	-	4.3	866.1
	22,839.6									2,263.8	21,014.5	23,278.3	446.4	16.4	2,694.1
Lbs/day	451,029									148,643					169,969
Ave.M.Wt.	19.75									65.66					63.09

Net Absorption = 446.4-16.4 -= 430 Mols/Day, Then (L/V) ave = (2263.8 + 215)/(22,839.6 - 215) = 0.1095 (checks assumed value)

Establish the absorber top tray temperature: Assume 22 F.

Component	Absorb. Overh. V_1Y_1 Mols/Day	3000# C.P. 22F. K 700#A	$\frac{V_1Y_1}{K}$	Top Tray Liquid L_1X_1 Mols/Day	Top Tray Liquid-Saturated Lean Oil $(L_1X_1 - L_oX_o)$ Mols/Day	Lbs/Day	ΔH Btu/Lb.	Heat of Absorption $(L_1X_1 - L_oX_o)\Delta H$ Btu/Day
CO_2	99.7	0.568	175.5	19.0	1.9	83.6	86.5	7,231
N_2	445.0	12.72	35.0	3. 8	-0.1	-2.8	81.0	- 227
C_1	17,962.6	3.384	530.81	574.6	-12.2	-195.2	152.5	-29,768
C_2	3,344.7	0.60	5,574.5	603.4	51.4	1,542.0	137.3	211,717
C_3	535.0	0.178	3,005.6	325.4	103.5	4,554.0	132.0	601,128
iC_4	11.1	0.0767	144.7	15.7	8.7	504.6	125.5	63,327
nC_4	7.2	0.0563	127.9	13.8	8.8	510.4	133.6	68,189
Lean Oil	4.0*	0.0005	8,038.0	870.1	-	-	-	-
	22,409.3		22,409.3	2,425.8				921,597
Lbs./day	429,703							
Ave.M.Wt.	19.17							

Top section heat of absorption per pound of saturated lean oil = 921,597/148,643 = 6.2 Btu/lb.

Heat capacity of saturated lean oil = 0.52 Btu/lb. - °F.

Rise in Temperature = 6.2/0.52 = 11.9 F.

Then top tray temperature = 10 + 11.9 = 21.9 F. (checks assumed value)

* Calculated to fill the "vol" in lean oil

Rich Oil temperature by heat balance around absorber:

Stream	Temperature, F.	Lbs/Day	Btu/lb.	Heat In, Btu/day	Heat out, Btu/day
Rich Gas	10	451,029	273.5	123,356,400	
Saturated Lean Oil	10	148,643	102.0	15,161,600	
Absorber Overhead	22	429,703	280.3	-	120,445,800
Rich Oil	T_{RO}	169,969	h_{RO}	-	18,072,200
				138,518,000	138,518,000

h_{RO} = 18,072,200/169,969 = 106.3 Btu/lb. Then T_{RO} = 17 F.

TRIAL NO. 3

Propane Recovery 57.5% = 424.4 mols/day, No. of Theoretical Trays = 4.0, Average Temperature = 30 F., Average (L/V) = 0.1161

For Propane: A = 0.59235, E' = 0.5542, Vn+1Yn+1 E' = 408.7, E'/A = 0.9356, L_0X_0 = (424.4-408.7)/(1-0.9356) = 243.9 mols/day, KV/L = 313.1/243.9 = 1.2836, V/L = 8.4445

	Rich Gas Vn+1Yn+1 Mols/Day	3000#C.P. K 30 F 700# A	A=L/KV	E'	(Vn+1Yn+1)x (1-E') Mols/Day	E'/A	3000#C.P. K 70 F 700#A	V/L = 8.4445 (KV/L)+1	(KV/L+1)-(E'/A)	Satur. Lean Oil L_0X_0 Mols/Day	Res.Gas V_0Y_0 Mols/Day	Exch. Feed Vn+1Yn+1 + Lean Oil Mols/Day	Absorbed Mols/Day	Stripped Mols/Day	Rich Oil LnXn Mols/Day
CO_2	101.9	0.60	0.1935	0.1935	82.2	1.0	0.52	5.3911	4.3911	18.7	82.2	100.9	1.0	-	19.7
N_2	444.9	13.2	0.0088	0.0088	441.0	1.0	12.2	104.023	103.023	4.3	441.0	445.3	-	0.4	3.9
C_1	17,950.6	3.52	0.03298	0.03298	17,358.0	1.0	3.19	27.938	26.938	644.4	17,358.5	18,002.9	-	52.3	592.1
C_2	3,399.8	0.642	0.18084	0.18084	2,784.5	1.0	0.545	5.6023	4.6023	605.1	2,785.0	3,390.1	9.7	-	614.8
C_3	737.5	0.196	0.59235	0.5542	328.8	0.9356	0.152	2.2836	1.3480	243.9	313.1	557.0	180.5	-	424.4
IC_4	65.0	0.0865	1.342	0.8975	6.7	0.669	0.064	1.540	0.871	7.6	4.1	11.7	53.3	-	60.9
nC_4	104.7	0.064	1.814	0.935	4.9	0.525	0.0465	1.393	0.868	5.7	2.2	7.9	96.8	-	102.5
IC_5	21.6	0.0287	4.045	1.0						1,529.7	20,986.1		21.6	-	21.6
nC_5	10.1	0.0224	5.183	1.0									10.1	-	10.1
C_6	3.2	0.0085	13.66	1.0									3.2	-	3.2
C_{7+}	0.3	0.0012	96.75	1.0									0.3	-	0.3
LO	-	0.00062	187.26	1.0			0.00036	1.00304		955.8	2.9	958.7	-	5.1	951.7
	22,839.6									2,485.5	20,989.0	23,474.5	376.5	57.8	2,805.2
Lbs/Day	451,029									163,252					181,454
Ave.M.Wt.	19.75									65.68					64.68

Net Absorption = 376.5 - 57.8 = 318.7 mols/day, Then (L/V) ave. = (2485.5 + 159.3)/(22,839.6 - 159.3) = 0.1166 (checks assumed value)

Establish the absorber top tray temperature: Assume 23 F

Component	Absorb. Overh. V_1Y_1 Mols/Day	3000# C.P. K 23 F 700#A	V_1Y_1 / K	Top Tray Liquid L_1X_1 Mols/Day	Top Tray Liquid-Saturated Lean Oil $(L_1X_1 - L_0X_0)$ Mols/Day	Lbs/Day	ΔH Btu/Lb.	Heat of Absorption $(L_1X_1 - L_0X_0)\Delta H$ Btu/Day
CO_2	100.9	0.572	176.4	20.9	2.2	96.8	86.5	8,373
N_2	445.3	12.38	34.8	4.1	-0.2	-5.6	81.0	- 454
C_1	18,002.9	3.401	5,293.4	628.8	-15.6	-249.6	152.5	-38,064
C_2	3,390.1	0.606	5,597.9	665.0	59.9	1,797.0	137.3	246,728
C_3	557.0	0.1806	3,084.2	366.4	122.5	5,390.0	132.0	711,480
IC_4	11.7	0.078	149.8	17.8	10.2	591.6	125.5	74,246
nC4	7.9	0.0574	137.6	16.3	10.6	614.8	133.6	82,137
Lean Oil	4.1*	0.00051	8,045.8	955.8	-	-	-	-
	22,519.9		22,519.9	2,675.1				1,084,446
Lbs/day	432,827							
Ave.M.Wt.	19.22							

Top section heat of absorption per pound of saturated lean oil = 1,084,446/163,252 = 6.6 Btu/lb.

Heat capacity of saturated lean oil = 0.52 Btu/lb. - °F.

Rise in temperature = 6.2/0.52 = 12.7 F

Then top tray temperature 10 + 12.7 = 22.7 F. (checks assumed value)

* Calculated to fill the "void" in lean oil

Estimate Rich Oil temperature by heat balance around absorber:

Stream	Temperature, F.	Lbs/Day	Btu/lb.	Heat in, Btu/day	Heat out, Btu/day
Rich Gas	10	451,029	273.5	123,356,400	-
Saturated Lean Oil	10	163,252	102.0	16,651,700	-
Absorber Overhead	23	432,827	280.5	-	121,408,000
Rich Oil	T_{RO}	181,454	h_{RO}	-	18,600,100
				140,008,100	140,008,100

Then h_{RO} = 18,600,100/181,454 = 102.5 Btu/lb, and T_{RO} = 10 F

RESULTS AND CONCLUSION

Comparison of absorption factor A_1, for the three cases.

	20 F $(L/V)_{top} = 0.0954$			25 F $(L/V)_{top} = 0.1042$			30 F $(L/V)_{top} = 0.1098$		
	A (assumed)	A_1	Δ	A (assumed)	A_1	Δ	A (assumed)	A_1	Δ
CO_2	0.1854	0.1691	0.0163	0.1896	0.1834	0.0062	0.1935	0.1995	-0.0060
N_2	0.0082	0.0075	0.0007	0.0085	0.0082	0.0003	0.0088	0.0089	-0.0001
C_1	0.031	0.0283	0.0027	0.032	0.0308	0.0012	0.033	0.0335	-0.0005
C_2	0.1759	0.1603	0.0156	0.1786	0.1737	0.0049	0.1808	0.1883	-0.0071
C_3	0.5596	0.5420	0.0176	0.5946	0.5853	0.0093	0.5924	0.6318	-0.0394
iC_4	1.3933	1.262	0.1313	1.3665	1.3585	0.008	1.342	1.463	-0.121
nC_4	1.9011	1.722	0.1791	1.855	1.851	0.004	1.814	1.988	-0.174

Optimum temperature is 25 F.

NOTES:

Equilibrium Constants from NGAA.
Enthalpy Charts: M. W. Kellogg and Company
Heats of Absorption:

$$\Delta H = \left(\frac{R}{M}\right)\left[(T_1T_2)/(T_2 - T_1)\right]\left(1n\frac{K_2}{K_1}\right)$$

Where

ΔH = Btu/# of component at average temperature between T_1 and T_2

K = Equilibrium constant

R = Gas constant, 1.99 Btu/#Mol/deg Rankin

T_1, T_2 = Temperature, Rankin

M = Molecular weight

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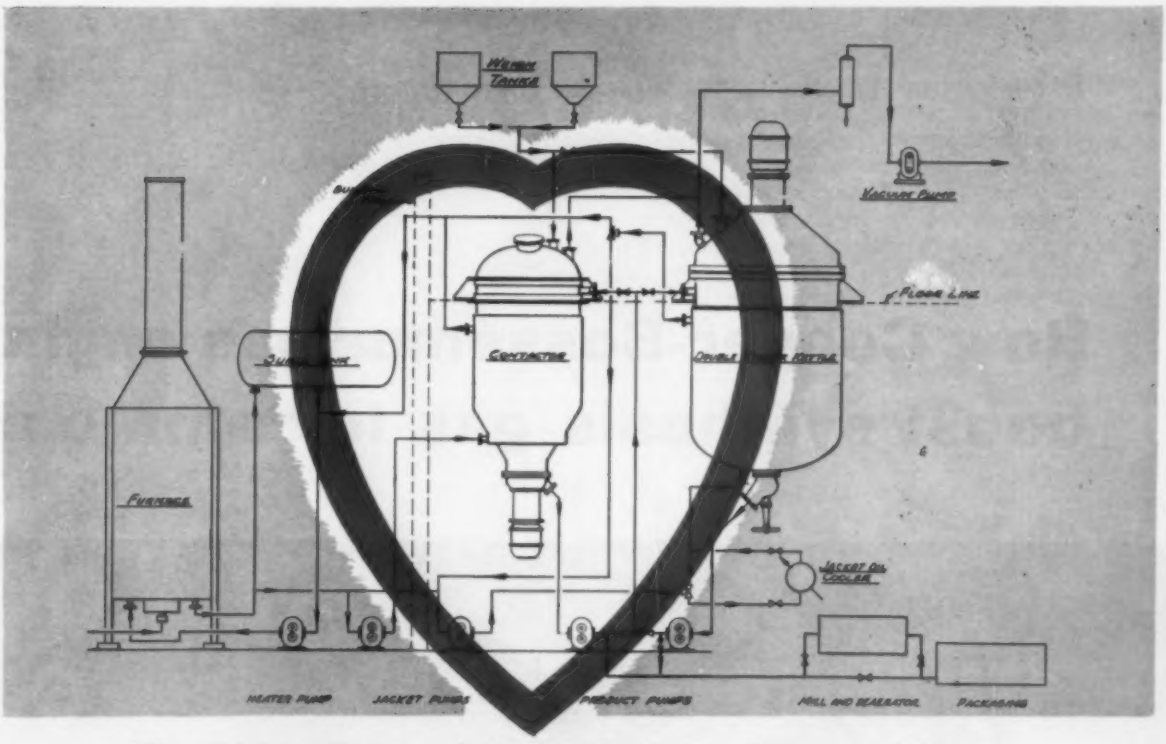

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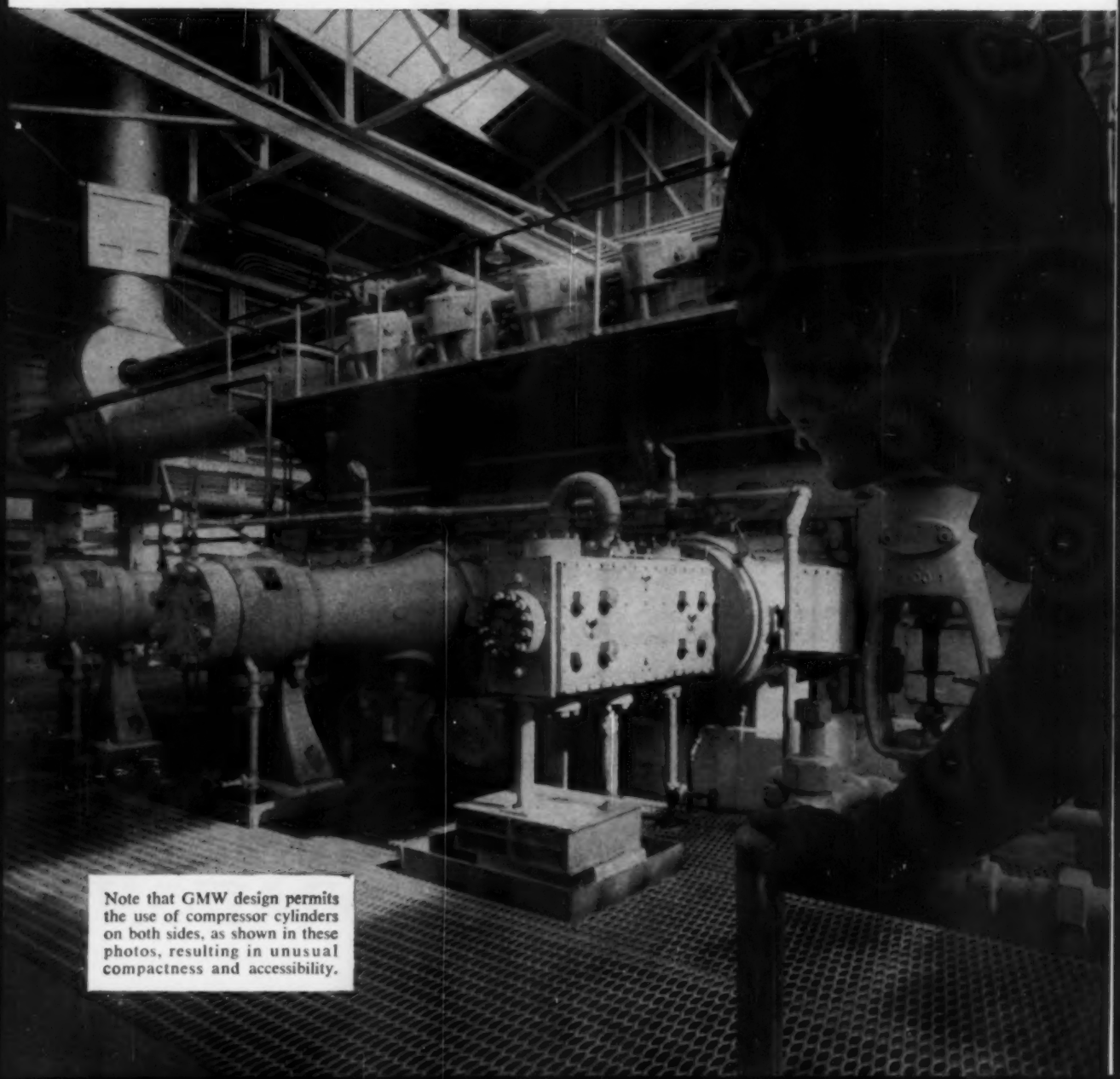
Report from American Cyanamid, Fortier Plant...

How Cooper-Bessemer gas engine boost synthesis gas for ammonia



Note that GMW design permits the use of compressor cylinders on both sides, as shown in these photos, resulting in unusual compactness and accessibility.

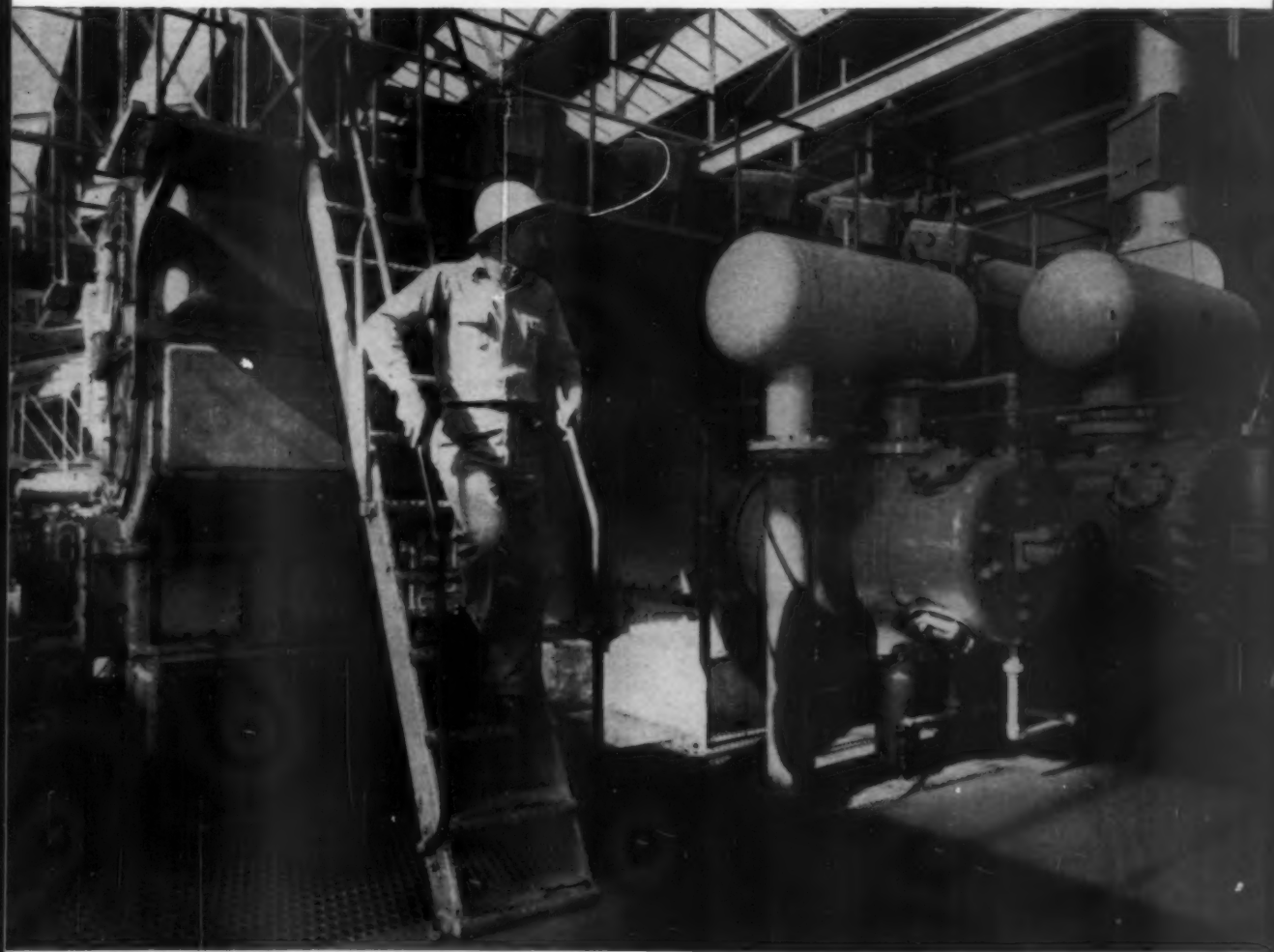
compressors to 5000 psi

These photos show both sides of one of the two Cooper-Bessemer 2500 hp GMW gas engine compressors at the Fortier Plant of American Cyanamid Company, Avondale, Louisiana. In the production of anhydrous ammonia, these 4-stage units compress 6000 cfm of synthesis gas from 60 psi to a discharge of 5000 psi. The left-hand view shows the high pressure cylinders; that on the right shows the low pressure side. The four stages of compression from 60 psi are (1) to 225 psi, (2) to 670 psi, (3) to 1500 psi, (4) to 5000 psi.

The two units have been operating since 1954, 24 hours a day, 340 days a year.

The anhydrous ammonia produced at the Fortier Plant is used by American Cyanamid in the manufacture of Acrylonitrile and is sold to fertilizer plants and other chemical companies.

Find out how Cooper-Bessemer can help *you* plan compression and power facilities. Write for copy of bulletin, "Cooper-Bessemer Equipment for Chemical Plants."



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ALUMINUM CHLORIDE!

98% pure or better. Meets rigid chemical specifications. Available coarse screened, medium screened, fine screened, extra fine grind.

Used for producing detergent intermediates and other alkylates . . . isomerization . . . polymerization . . . varied Friedel-Crafts syntheses.

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New Equipment

Indicating Transmitters

The Model 45 Series, a new line of pneumatic indicating transmitters for pressure flow, temperature, liquid level, differential pressure, and dew point has been introduced. Transmitters have high ambient temperature stability, with less than ½ percent error for ambient temperature changes as great as 50 F, regardless of the variable measured. *The Foxboro Company.*

Circle number (41) on reply card.

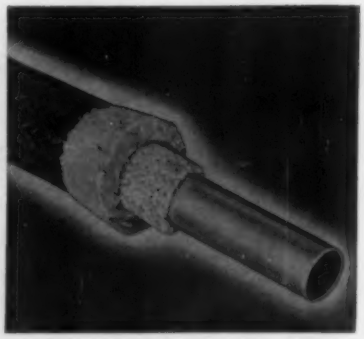
King Size Tank Cars

Two railroad tank cars of 30,000 gal shell capacity—largest ever designed and constructed—are being built for Tuloma Gas Products Company, Tulsa, LPG marketer. New Hot Dog—30 cars will measure 85 ft over the couplers and will be 17 ft longer and have nearly a third more shell capacity than largest rail tank cars now in interchange service for transport of bulk liquid products. *Union Tank Car Company.*

Circle number (42) on reply card.

Insulated Pipe Covering

Unarco Insutube is light-weight, noncombustible flexible tubing designed for temperatures from 50 to 500 F. Is for insulating bent piping or tubing, where use



of rigid material is impractical; for insulating flexible connecting lines, and for conditions of severe vibration. Comes in tube sizes from ¼ to 1 in., in increments of ⅛ in., and in 1½ and 2-in. sizes. *Union Asbestos & Rubber Company.*

Circle number (43) on reply card.

Process Chromatograph

New CEC Type 26-212 Process Chromatograph makes analyses of up to 8 streams in 1/20th to 1/50th time required by conventional chromatographs, depending upon the product. Many analyses take less than 30 seconds. Chromatograph is composed of analyzer unit, with explosion-proof housing for onstream installation in hazardous areas, and separate control unit, which can be located on control panel as far as 500 ft from analyzer. *Consolidated Electrodynamics Corp.*

Circle number (44) on reply card.

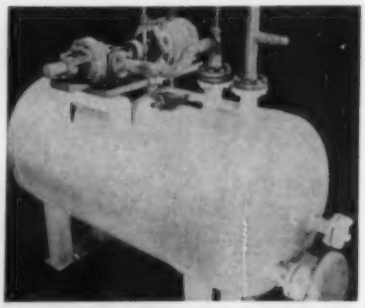
New Steam Trap

New thermostatic steam trap has union built into trap inlet, saving time involved in fitting pipe to union and cost of separate union and materials. Trap can be disconnected for maintenance by loosening a single fitting. Available as optional feature in both ½ and ¾-in. sizes. *V. D. Anderson Company.*

Circle number (45) on reply card.

Vacuum Pump System

Faster unloading of antiknock compounds at refineries is now possible with a new system composed of a vacuum



pump with motor and a 300-gal tank partially filled with a hydrocarbon sealant. System can be tied in with an existing TEL mixing plant at a refinery or built as part of a new plant. *Ethyl Corporation.*

Circle number (46) on reply card.

Lubricated Plug Valve

Tank bottom valve leakage is prevented by Nordstrom lubricated plug valve, which provides tight shut-off despite pressure head in tank. Compact construction permits installation where conventional units might not fit. Easy, quarter-turn open-close action enables operating personnel to work efficiently in the cramped space. *Rockwell Manufacturing Company.*

Circle number (47) on reply card.

Couplings and Fittings

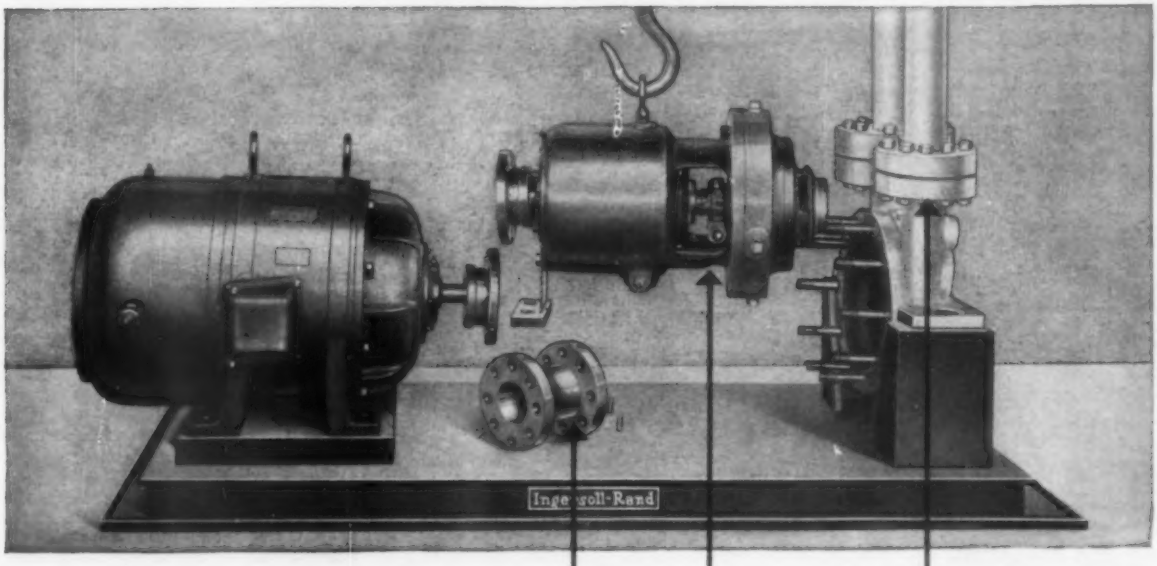
Plain or beveled end pipe may be connected easily and securely with Plainlock Couplings and Fittings, available in 1, 2, 2½, 3, 4, and 6-in. sizes. Fittings come with plain ends or in combination of plain and grooved, threaded or flanged ends for interconnections of other piping systems. *Victaulic Company of America.*

Circle number (48) on reply card.

Why I-R process pumps are

SO EASY

to maintain



SIMPLY BY REMOVING THE SPACER COUPLING

THE ENTIRE PUMPING ASSEMBLY

CAN BE LIFTED OUT WITHOUT DISTURBING THE DRIVER OR PIPING

EASY ACCESS is just one of *many* features that make Ingersoll-Rand process pumps easier and more economical to inspect and maintain. Saving down-time by speeding disassembly and reassembly is a big asset. But even more important is the extra stamina and dependability that keeps these pumps *on the line* longer with no interruptions of service.

Maintenance-saving features include vibration-free balanced impellers, rugged casing with generous corrosion allowance, rigid precision ground heat-treated shafts, extra-deep stuffing boxes and completely removable split-type glands. For complete information, contact your nearest Ingersoll-Rand sales engineer.

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COMPRESSORS • GAS & DIESEL ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

. . . one of a series presented by Western Supply Company, Tulsa, to improve the "I.Q."* of engineers . . . (*"Income Quotient")

Design Economics of Heat Exchangers Furnish Basis for Heat Transfer Cost Engineering

The application of cost engineering practices in the accurate evaluation of capital equipment in the process industries is rapidly becoming more and more vital to the management of process companies, as margins of profit grow narrower.

Management now depends increasingly, therefore, on modern cost-engineering practices to evaluate realistically the true, long-range economy of a given piece of equipment in relation to its initial cost, cost of installation, maintenance, operation, labor, replacement — and in relation to the productivity or profit of the process involved.

The importance of efficient, practical, long-range forecasting is increasingly a focal point in the process industries as a whole, but no where is it more important than in the purchase and operation of heat exchangers for use in continuous flow processes, where the operation of the unit never ceases, and therefore must be calculated on a basis of maximum longevity, efficiency and service. Included in the design of each heat exchanger must be a consideration of its initial cost, its cost of installation (including piping, fittings, valves, flanges, etc.), its operation and maintenance (including corrosion-protection, mechanical maintenance, cleaning, re-tubing, replacement parts) — and the factor of labor costs attendant to the installation, operation, maintenance and/or replacement of the unit.

In each case, however, the basic factors must be considered and determined: capital, overhead, maintenance and unit process costs.

The Cost Engineer, therefore, must be committed to continual study, re-examination and revaluation of every area which contributes to the practice of chemical engineering, for it is from his fundamental and technical knowledge of the process involved that his eventual forecasts for productivity, efficiency and longevity must ultimately spring.

Considerable thought has been given to the "ideal" background or qualifications for the Cost Engineer. Certainly his primary requisite must be a thorough knowledge of chemical engineering, including, in the heat transfer field, an equally intimate grasp of the thermal and metallurgical engineering so vital to an understanding of heat exchanger design economics.

Secondly, he should have had practical experience in the production phases of the chemical business. Thirdly, he will be better equipped to understand the complexities of the "business" side of such evaluations, if he has had education and/or experience in a certain amount of business administration.

Clear, concise, understandable communications is another factor of great importance to the ultimate success of the Cost Engineer, for he must transmit his findings, make his recommendations and defend his decisions to a number of widely varied types of people, some with technical background and others with little or no technical knowledge.

The Cost Engineer must be tireless on detail, inquisitive at each point, yet tactful in his demands on subordinates and associates. Above all, although cost engineering presents a real challenge to his analytical mind, he must serve his purpose with genuine humility, cognizant of the amount he has yet to learn.

In short, he should have a proclivity towards the functions of management, for that is where he might very well be headed.

(FOOTNOTE: For more detailed information on this subject, write for your free copy of "Cost Engineering" to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and for immediate assistance on heat transfer cost engineering, feel free to suggest our services . . . whether or not there's a heat exchanger in your company's future!

New Literature

API Standard 1202 . . . new standard for measuring, sampling, and calculating tank car quantities and calibrating tank car tanks (pressure-type tank cars) is revision of API Code 1202, published in 1951. ($1). *American Petroleum Institute.*

Circle number (49) on reply card.

Armolads . . . title of booklet describing dispersants and inhibitors which prevent formation of sludge in fuel oils stored for extended periods. *Armour Industrial Chemical Company.*

Circle number (50) on reply card.

Chemicals for Refiners . . . and their physical and chemical properties are discussed in new 4-page reference guide. *Armour Industrial Chemical Company.*

Circle number (51) on reply card.

Chempumps . . . high-pressure line of sealless leak-proof pumps, is described in new 4-page Bulletin 1070-1. *Fostoria Corporation.*

Circle number (52) on reply card.

Electronic Computer . . . RPC-4000, fully-transistorized, stored program general purpose computing system for engineering and business data processing is described in brochure S-483. *Royal McBee Corporation.*

Circle number (53) on reply card.

Gages and Instruments . . . for the process industries are detailed in Bulletin 3015, which provides quick roundup of company's products to simplify the engineer's job of selecting the right device. *American Machine and Metals, Inc.*

Circle number (54) on reply card.

Glassed-Steel Reactor . . . installation, operation, and maintenance procedures are detailed in Bulletin 983. Section devoted to thermal shock. *The Pfaudler Co.*

Circle number (55) on reply card.

Hi-Seal Fittings . . . are described in Catalog 3108, full of technical data of value to engineers connected with tube circuitry. Also included is first printed material on Braze-Seal Fittings for extra high pressure and temperature. *The Imperial Brass Manufacturing Co.*

Circle number (56) on reply card.

Hydra-Set . . . auxiliary crane and hoist control instrument, is discussed in Bulletin H-21. A closed circuit, hydraulically operated instrument, Hydra-Set installs between crane hook and load. Will raise or lower up to 100 tons a distance of 12 in. with accuracy to within 1/1000th in. *Mefco Sales & Service, Inc.*

Circle number (57) on reply card.

Hydrocool Nozzles . . . for inspirating gas burners, are described in Bulletin 57. Improved nozzles provide safe operation with hydrogen or hydrogen-rich gases in various furnaces; also assure efficient burning of any other gas. *National Airoil Burner Co.*

Circle number (58) on reply card.

Instruction Book . . . Form 5845 gives operation and maintenance procedures for automatically controlled Exide vertical-line, single-circuit, motor-generator chargers for lead-acid storage batteries. *The Electric Storage Battery Co.*

Circle number (59) on reply card.

Ketones . . . as solvents and chemical intermediates are treated in 48-page booklet. Comprehensive bibliography on ketones and their uses is included. *Union Carbide Chemicals Company.*

Circle number (60) on reply card.

Latent Heat Transfer . . . from steam to a product is subject of Reprint 126 "The Evolution of Condensate Drainage and How Jet Action Provides the 'Missing Link'." *Cochrane Corporation.*

Circle number (61) on reply card.

Leak Detection Hints . . . tables of conversion factors, formulae, performance charts, hints, and other information for users of mass spectrometer-type leak detectors is contained in Bulletin 1857. *Consolidated Electrodynamics Corporation.*

Circle number (62) on reply card.

Process Heating Problems . . . are treated in Bulletin 102.2, which describes how liquid heat transfer units for heating jacketed equipment of all types can be used to advantage in process industries. *Hynes Electric Heating Co.*

Circle number (63) on reply card.

Product Guide . . . tabulates physical properties and shipment methods for 1,3-butadiene, ethane, ethylene, methane, propylene, biphenyl, dicyclopentadiene, naphthalene, tetrahydronaphthalene, toluene, unsaturate oil, calcium hydroxide, calcium oxide, acetylene, and calcium carbide. *Union Carbide Olefins Company.*

Circle number (64) on reply card.

Protective Coatings . . . and specific application problems are described in new brochure which also gives data on results of three years of corrosion tests. *The Glidden Company.*

Circle number (65) on reply card.

Prufcoat Primastic . . . 1-coat protective coating combining rust-inhibitive primer properties with both organic and inorganic chemical resistance is explained in Bulletin 540A. *Prufcoat Laboratories, Inc.*

Circle number (66) on reply card.

Pulsafeeder Pumps . . . designed to solve pumping problems where hard-to-handle chemicals or accurate metering is involved, are discussed in 28-page Catalog 59. *Lapp Insulator Company, Inc.*

Circle number (67) on reply card.

Pumps in Operation . . . Data Sheet D-59-1 explains how controlled volume pumps solved problem of metering softening agent into distribution lines at two water pumping stations now in operation. *Milton Roy Company.*

Circle number (68) on reply card.

Hydro-Valves . . . Series DH for liquid service is subject of Bulletin L-100/59, which gives details and specifications on sizes, capacities, materials, other pertinent data. *J. E. Lonergan Company.*
Circle number (69) on reply card.

Radiant Heaters . . . Vycor Tubular Heaters and Pyrex Panel Heaters for drying, heating, baking, and curing are subject of Bulletin PE-70. *Corning Glass Works.*
Circle number (70) on reply card.

Safety Guides . . . is new pamphlet series on safety in chemical manufacturing. SG-1, now available, is entitled "Health Factors in Safe Handling of Chemicals." (15 cents) *Manufacturing Chemists' Association, Inc.*
Circle number (71) on reply card.

Scrubbers . . . application, construction, and operation information on the company's complete line, with data on sizes available and dimensions, are discussed in Bulletin 4R. *Schutte and Koerting Company.*
Circle number (72) on reply card.

Standby Electric Plants . . . are subject of 8-page folder which outlines points to be considered in selection of any emergency electric generating plant. *D. W. Onan & Sons, Inc.*
Circle number (73) on reply card.

Steam Turbine . . . single-stage, mechanical drive, centerline-mounted to minimize shaft misalignment due to thermal expansion, is detailed in Bulletin 2001. *Dean Hill Pump Company.*
Circle number (74) on reply card.

Tolad Fuel Additives . . . of both the inhibitor and the inhibitor-dispersant types are explained in new 4-page brochure. *Tretolite Company, div. of Petrolite Corporation.*
Circle number (75) on reply card.

Ventilating Equipment . . . new bulletin No. B-500, describes rigid vinyl and reinforced plastic collecting hoods, ducts and stacks, elbows and other fittings; includes listing of standard sizes, specifications and chemical resistance data. *Heil Process Equipment Corp.*
Circle number (76) on reply card.

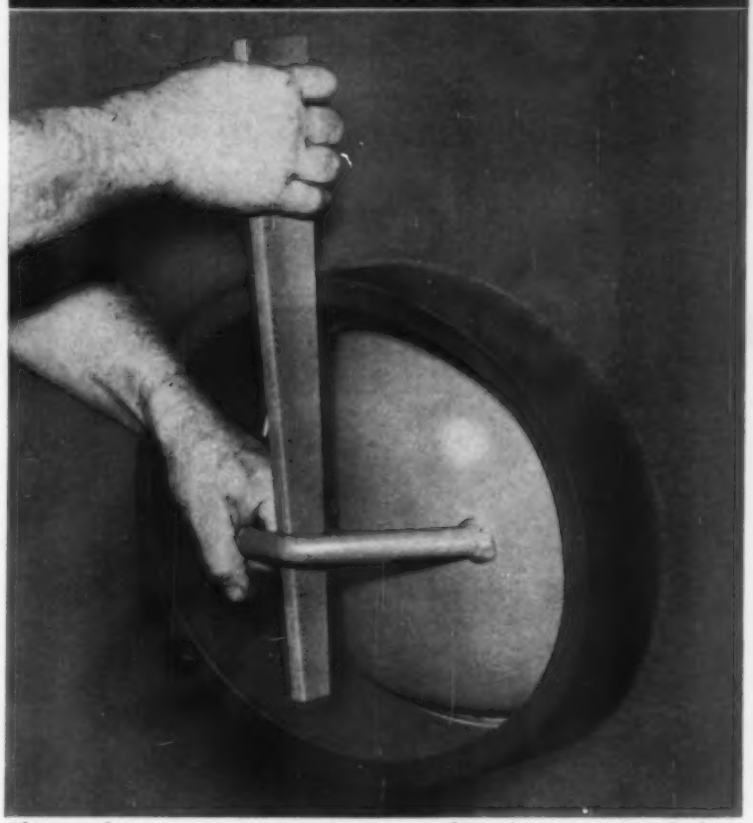
Valve Guide . . . new 20-page engineering data book gives dimensional and material specifications for all types of valves of various pressure ratings and alloys commonly used in the refining industry. *Kerotest Manufacturing Company.*
Circle number (77) on reply card.

Water Conditioning . . . data sheet "Solving an Unusual Case of Carryover" tells why internal baffling must be in good condition for production of pure steam. *Betz Laboratories, Inc.*
Circle number (78) on reply card.

Water Treating . . . new reprint covers automatic control of water treatment plants, contains two parts, is Technical Reprint T-179 and is entitled "Instrumentation for Water Treatment Plants." *Graver Water Conditioning Co.*
Circle number (79) on reply card.

Working data . . . on line of ion-exchange materials, with bibliography, is contained in new 12-page catalog. *BIO-RAD Laboratories.*
Circle number (80) on reply card.

NEW LENAPE WEDGE MANWAY
Eliminates Bolts and Yokes



This revolutionary, new manway is not only easier to open and close, but is actually more economical than conventional bolted covers. Noted for its simplicity, the Lenape Wedge Manway assembly is a unique combination of only three metal parts—ring, cover and key wedge, plus a standard gasket, and is supplied as a "package" assembly.

FAST, SIMPLE OPERATION—As illustrated, to close the manway you insert the key wedge under the cover handle and over the opposite ring wall. Then, merely tap the wedge gently with a hammer until a tight seal is secured. That's all there is to it. Troublesome bolts and yokes are completely eliminated. Uniform gasket loading is assured.

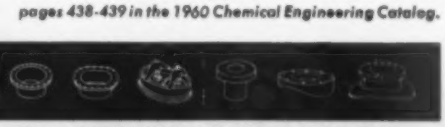
To open, you just tap out the wedge and remove the cover—all in a matter of seconds.

Write today for full details and prices on the amazing new Wedge Manway Assembly—another Lenape exclusive.

•*Patent pending*

See our standard line of pressure vessel connections on pages 438-439 in the 1960 Chemical Engineering Catalog.

LENAPE PRESSURE VESSEL CONNECTIONS



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RED MAN PRODUCTS

For Speediest Repair of Corrosion Leaks in Pipe

JUNIOR

EMERGENCY PIPE CLAMP

Repair pipe leaks QUICKLY!

Speediest application — slotted lug permits the single plated bolt to slide instantly into place.

A companion to the old reliable Emergency Pipe Clamp that has served industry for a half century, the JUNIOR, a single bolt clamp, is 2⅞" wide. Undersells most band-type clamps.

Made of malleable iron, ruggedly proportioned, with full-length hinge along one side. Formed to exact pipe size—no bending. The recessed pressure-equalizing gasket, entire width of clamp, is cemented in. A lasting installation. 2" pipe size—$1.80; 2½"—$2.20; 3"—$2.30. Write for new circular on the Junior.

SKINNER-SEAL

EMERGENCY PIPE CLAMPS for safe, sure lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12", for steel and C. I. pipe. Stocked by practically all oil supply stores.

Send for catalog!

M. B. SKINNER CO.

SOUTH BEND 21, INDIANA

REFINING PERSONALS

▸ **John T. Pinkston** has been elected a vice president of United Engineers & Constructors Inc., Philadelphia. He will retain his responsibility as process consultant and will be in charge of all the firm's process development activity and also its activities in the gas industry.

J. T. Pinkston

R. W. Faulk

▸ **R. W. Faulk** will become manufacturing vice president of Shell Oil Company of Canada, Ltd., July 1, succeeding **G. Davidson,** who will retire after 34 years' service. Faulk, now manager of Shell Oil Company's Norco, Louisiana, refinery, will be succeeded there by **L. T. Wilson,** presently manager of Shell of Canada's Montreal refinery.

▸ **John H. Erbar,** who recently received his PhD in chemical engineering at Oklahoma State University, has accepted a position as research engineer in refinery technical service at the Richmond laboratory of California Research Corporation. He is co-author of an article in this issue of *Refining Engineer.*

▸ **Dr. Ernest W. Thiele,** development coordinator of the Whiting research laboratories of Standard Oil Company (Indiana), retired on annuity March 1. He, along with **Dr. Warren L. McCabe,** developed the McCabe-Thiele method for calculating distillation.

▸ **David Glaser** is new chief process engineer in the technical services department of DX Sunray Oil Company, Duncan, Oklahoma.

▸ **Dudley P. Penick** has been appointed staff gas engineer for Mobil International Oil Company in New York, with staff responsibility for gas production, separation, processing, and utilization in all Mobil International operations.

▸ **George R. Kritzer** has been named Houston sales manager of Yuba Consolidated Industries, Inc. He will direct sales for several manufacturing divisions serving the heavy construction, petroleum, chemical, and power industries.

▸ **Dr. Adalbert Farkas,** internationally known scientist in catalysis and petrochemicals, has been named assistant director of research at Houdry Process Corporation, Philadelphia, a leading process licensor and manufacturer of catalysts and chemicals. He previously headed the organic research section.

▸ Trinity Steel Company, Inc., Dallas, has named **Elmer E. Garnsey** vice president in charge of sales, according to **W. Ray Wallace,** president. The company, which pioneered steel fabricating in the LPG industry, recently began building a line of pressure vessels, bulk liquid trailers, and tanks for the petrochemical and petroleum industries.

▸ **Rudy P. Lowe** is a newly elected vice president of B-I-F Industries, Inc., Providence, Rhode Island, manufacturers of blenders, instruments, and feeders for positive control of materials in motion in petroleum, petrochemical, and process industries as well as in water and waste treatment plants. Lowe continues as director of industrial systems sales.

▸ **James W. Bateman,** Houston, has been promoted to the newly created position of assistant manager of Continental Oil Company's Lake Charles, Louisiana, refinery. He formerly was assistant manager of the company's coordinating and planning department.

J. W. Bateman

M. J. Asensio

▸ **Lt. Gen. Manuel J. Asensio,** USAF ret. has joined Texas Butadiene & Chemical International Ltd., to become chief executive officer of the Argentine company the firm is organizing. He will establish headquarters in Buenos Aires.

▸ **Donald W. Darnell,** board chairman of The Fluor Corporation, Ltd., Los Angeles, has been elected president of the National Constructors Association for 1960. Other officers are **Robert L. Cashen,** H. K. Ferguson Company, Cleveland, vice president, and **H. E. Lore,** Dravo Corporation, Pittsburgh; **George R. Collins,** The Lummus Company, New York, and **A. E. Somerville,** Arthur G. McKee & Company, Cleveland, members of the executive committee.

▸ **W. L. Martin** has been promoted to staff engineer, and **H. A. Ward, Jr.,** to senior mechanical engineer in technical division at Humble Oil & Refining Company's Baytown, Texas, refinery.

▸ **Dr. John W. Ryznar,** vice president and technical director of Nalco Chemical Company has been promoted to the new position of technical representative in corporate management. Ryznar will be responsible for planning, guiding, and coordinating all technical activities of the Chicago-based industrial chemical manufacturing firm and its subsidiaries.

▸ **A. Russell Young** has been appointed Assistant Executive Vice President and General Manager of J. F. Pritchard and Co., engineers and constructors, serving the natural gas, petroleum, chemical and power industries.

▸ **Wayne Elledge** has been promoted to Chief Project and Mechanical Engineer for El Paso Natural Gas Products Company with **George Harrison** succeeding him as Plant Engineer at the company's Ciniza, New Mexico, refinery, and **Don Watzke** in turn succeeding Harrison as Chief Inspector for the company.

▸ **Norman J. Smith** has been named chief engineer of the instrument division of J. E. Lonergan Company. Smith, who has been issued 32 patents pertaining to instruments and gages, previously was a research scientist in computer and associated equipment design for Philco Corporation.

▸ Appointment of **Henry J. D'Aragon** as vice president of Yuba Consolidated Industries, Inc., has been announced by **John L. McGara,** president. D'Aragon, who will headquarter in New York, is former general sales manager of Graver Tank and Manufacturing Company, New York.

▸ **Bryson Filbert** has been appointed Chemical Products Advisor to the refining coordination department of Standard Oil Co. (N.J.). He was formerly manager of manufacturing in Bogota for International Petroleum (Colombia) Ltd., an affiliated company.

for **leakproof, pressure-tight connections**

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SEALING COMPOUNDS

Heat and vibration-proof, non-solvent, will not shrink, crack or crumble. Makes all assemblies leak-proof and pressure-tight. Prevents rust, corrosion, joint seizure.

7 BASIC BLENDS

LIQUID WRENCH®

The super-penetrating rust solvent

LOOSENS rusted bolts, nuts, screws, 'frozen' parts

Liquid Wrench works *fast*... yet is absolutely safe for all metals and alloys.

2171

At Industrial, Automotive, Hardware, Plumbing Jobbers

RADIATOR SPECIALTY CO.
Charlotte, North Carolina

SOLDER SEAL

▸ **Carl Pfeiffer** has been appointed as Process Engineer at SunOlin Chemical Company, engaged in technical economics and process design studies of chemical plants.

▸ **Ralph A. Larsen** is new chief design engineer of Stone & Webster Engineering Corporation, Boston, succeeding **Charles D. Lilburn,** who was named design consultant.

▸ **Harry M. Howarth,** senior staff engineer in the general engineering department at Standard Oil Company in Whiting, Indiana, has been appointed chairman of Section 3, Code for Pressure Piping, Petroleum Refinery Piping. This group is under the direction of Sectional Committee B31 of the American Standards Association and is under the administrative sponsorship of the American Society of Mechanical Engineers.

▸ **Clifford E. Oman** has been named assistant to the director of production at U. S. Chemicals Company, division of National Distillers and Chemical Corporation. Succeeding Oman as general manager of the company's petrochemical plant complex at Tuscola, Illinois, is **James R. Smith,** formerly plant manager.

▸ **Earl J. James** has been appointed purchasing manager of Mobil Oil Company's Beaumont, Texas refinery, succeeding **W. B. Johnson,** who is retiring.

▸ M. W. Kellogg Company announces appointment of **W. O. Jacobs** as western sales representative, with offices in Los Angeles, and **Kenneth H. MacWatt** as manager of sales, fabricated products division, based in New York.

▸ **D. W. Blend** has been elected a director and vice president, operations, of Calumet & Hecla, Inc., Chicago. Previously he was vice president of the company and general manager of the Wolverine Tube Division.

▸ **J. M. Williams,** chemical engineer, has been promoted to Senior Coordination Technician in Coordination Division at Humble Oil & Refining Company's Baytown, Texas, refinery.

▸ **M. H. Cutler,** Vice President and Engineering Manager of Stone & Webster Engineering Corporation, has announced the appointment of **John J. Niland** as Assistant Engineering Manager.

▸ **Harry W. Dudley,** Manager of Petrochemicals for Delhi-Taylor Oil Corp., has moved to the company's headquarters in Dallas, from the New York Sales Office.

▸ **J. A. Boege** has been named Manager of Technical Services at Mobil Oil Company's Torrance refinery, to be responsible for design, mechanical and project engineering.

▸ **D. C. Breland** has joined Petreco division of Petrolite Corporation at Houston, where his work will pertain to chemical and electrical dehydration, etc.

Choosing an Antioxidant?

Refinery customers have found that, in comparison with other inhibitors, Dalpac 4 (Hercules 2,6-di-tert-butyl-p-cresol) saves up to three dollars on every thousand barrels of gasoline produced. Dalpac 4 inhibits gum formation, stabilizes gasoline color, and helps maintain engine cleanliness. Refiners have also found it to be excellent in turbine and transformer oils where it prevents deterioration, and does not affect electrical properties.

For additional information write:

Oxychemicals Division
Naval Stores Department
HERCULES POWDER COMPANY
900 Market Street
Wilmington 99, Delaware

NOS9-5R

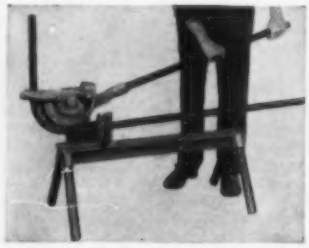
FAST, Lightweight
Greenlee Hydraulic Benders for 1/2"-4" Conduit and Pipe

full 90° bend with one ram stroke

NEW GREENLEE No. 883 Lightweight Hydraulic Pipe Bender quickly makes accurate bends in eight sizes of pipe from ½" through 3" . . . up to 90° with one ram stroke. Operates with either a portable power pump or hand pump. Makes 90° bend in 3" pipe in approximately 1 minute with power pump . . . only 10 minutes with hand pump. One set of rotating supports for all eight pipe sizes . . . supports also serve as rollers for wheeling bender from job to job. Pipe is easily inserted and removed from front of bender. "Quick-removal," positive-locking support pins cannot come loose. Bending gauge included for accurate results with minimum calculations. Get details now on the complete GREENLEE Lightweight Bender line that includes three models for ½" - 2" . . . ½" - 3" . . . and ½" - 4" pipe.

new, fast ratchet bender for ½", ¾", 1" pipe

GREENLEE No. 1800 Ratchet Hand Bender permits short, powerful strokes for easy, quick bending up to 90°. Swing-away clamp makes loading simple. Sturdy T-iron base sets anywhere or receives threaded pipe legs of any desired length. Built-in bending gauge reads 0 to 90°. See your distributor for a demonstration, or write for descriptive Bulletin E-291.



A COMPLETE LINE OF HYDRAULIC AND HAND BENDERS FOR PIPE AND TUBING

GREENLEE TOOL CO. GREENLEE

1737 Columbia Ave., Rockford, Illinois

▸ **Dr. Melvin De Groote,** vice president of research, development, and patents for Tretolite Company division of Petrolite Corporation, retired March 1. He is continuing his service with the company in a consulting capacity and retaining his office facilities at Petrolite's headquarters in Webster Groves, Missouri.

▸ Appointment of **Alex T. Sturrock** as senior development engineer, new products development, for Goodrich-Gulf Chemicals, Inc., has been announced by **Paul W. Cornell,** vice president. Formerly with the Moreland Corporation, Sturrock will head up new products applications for man-made rubbers at the corporate new product development laboratories, Institute, West Virginia.

▸ **Roy F. Brown** has been promoted to the position of marketing manager for the scientific and process instruments division of Beckman Instruments, Inc., with headquarters at Fullerton, California. He formerly was process sales manager for the division.

▸ **Dale F. Fink** has joined Shell Development Company's Emeryville Research Center staff as a research supervisor in the bitumen department. Fink previously was assistant chief research chemist at Shell's Wood River Research Laboratory.

▸ New director of marketing for National Carbon Company, Division of Union Carbide Corporation, is **Curry E. Ford.** Ford, who formerly was new products marketing manager, will have overall marketing responsibilities for the company's complete line of industrial carbon and graphite products.

▸ **J. W. Meehan** has been named president of The Vickers Refining Company, a newly created, separate division of The Vickers Petroleum Company, Inc., Wichita, Kansas. Meehan, who formerly was president of The Derby Refining Company, Wichita, also has been elected a director and made vice president of The Vickers Petroleum Company.

▸ The Atlantic Refining Company has announced appointment of **Byron E. Milner** as manager of the company's Atreco refinery at Port Arthur, Texas. Milner, general superintendent of the plant since 1957, succeeds **Paul L. Robison,** who is retiring after 34 years' service with Atlantic. **Albert W. Kusch** will succeed Milner as general superintendent.

▸ **William S. Nordburg, Jr.,** has been appointed to the newly created position of director of overseas projects for Amoco Chemicals Corporation. He will be responsible for evaluating opportunities overseas for various chemical activities and for developing commercial ventures. He formerly was director of licensing, research and development department, Standard Oil Company (Indiana).

Free to Subscribers!
Don't forget to order your 1959 Annual Index.
Write The Petroleum Engineer, Box 1589 Dallas 21, Texas

If distance is your problem

take a long look at *Lenkurt* carrier

ALL YOUR
COMMUNICATIONS NEEDS
FROM ONE
DEPENDABLE SOURCE

Lenkurt Type 32E Carrier Equipment is the most economical and efficient means of adding long-haul communications channels to existing wire lines.

By using single sideband suppressed carrier transmission and automatic pilot control, reliable communications under the most adverse weather conditions can be achieved over almost any distance.

Type 32E terminals are equipped with either 3 or 4 channels in the 3- to 35-kc range, and can be applied over v-f circuits. System levels and frequencies of the 3-channel equipment coordinate with those used in Western Electric Type C carrier units.

The AE-Lenkurt team of telephone engineers is equipped to handle as little or as much of the planning and installation as you wish. And AE will provide "follow-thru" service *for the life of the equipment*.

For full information on the Lenkurt Type 32E or companion equipment, call your Automatic Electric representative, or write the Director, Petroleum Sales, Automatic Electric Sales Corporation, Northlake, Illinois.

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Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

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GASO DISTRIBUTORS BRING GASO SERVICE TO YOUR BASE OF OPERATIONS

We screen and pick our distributors with the utmost care. We bring their organizations to Tulsa for thorough training in oil-industry pumps and their application. We insist that they carry stocks of Gaso Pumps and parts.

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MOTOROLA
"Handie-Talkie"®

2-WAY POCKET RADIO

pocket receiver (actual size)

All new...welds your crewmen into a closer working, *better* working "team"

Construction crews . . . maintenance men . . . supervisors . . . any men away from their vehicles can now *retain* 2-way radio contact at *all* times, for greater everyday efficiency and instant emergency communication.

Here are individual receivers and transmitters that can be carried in the pocket or worn on the belt to give excellent local 2-way coverage.

The new "Handie-Talkie" Pocket Receiver is fully transistorized for low power drain and high reliability. With the most powerful audio output available, messages can be clearly heard even in noisy areas. Available with rechargeable battery, or standard mercury cells which give up to 200 hours of operation. Write for complete information today.

The companion "Handie-Talkie" Pocket Transmitter has 2 to 4 times the power of similar units. With the Pocket Receiver you can have complete, lightweight, *personal* 2-way radio communications.

MOTOROLA 2-WAY POCKET RADIO

Motorola Communications & Electronics, Inc., 4501 Augusta Blvd., Chicago 51, Ill. • A Subsidiary of Motorola Inc.

Frank Friedli, *Manager,*
En-Tronic Controls Division,
The Cooper-Bessemer Corporation,
explains...

How Cooper-Bessemer En-Tronic® Controls operate compressor station 26 miles away

This electronic control at Robinson Station transmits the signals for completely automatic remote control of the Columbiana Station 26 miles away. It receives and charts data from that station and provides an alarm and lights to indicate conditions at the remote station. All this is carried by a single line.

A part of the gas stored for East Ohio's customers is handled by their Columbiana Station. Here, they have recently replaced a 40-year-old engine-driven compressor with a Cooper-Bessemer GMXD 660 hp Packaged Compressor and En-Tronic Control. This entire installation operates automatically by push-button control from the Robinson Station 26 miles away.

A single telephone line and tone equipment provide a series of frequencies which control all operations... automatic sequencing, system alarms, data reporting, opening and closing of plug valves in the station piping, instantaneous shutting down of compressor in case of failure of power or communications and automatic starting when services are restored, and all other control and regulating functions. The compressor is self-lubricating.

The Cooper-Bessemer equipment makes possible better utilization of skilled operators, greater dependability of control, and a considerable economy in operation.

Why not investigate remote control for your compressor stations... both new and modernized. Call on us for help in evaluating the possibilities.

BRANCH OFFICES: Grove City • New York • Washington • Gloucester Pittsburgh • Chicago • Minneapolis • St. Louis • Kansas City • Tulsa • New Orleans • Shreveport • Houston • Greggton • Dallas • Odessa • Pampa Casper • Seattle • San Francisco • Los Angeles

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Cooper-Bessemer International Corp.... New York • Caracas • Anaco

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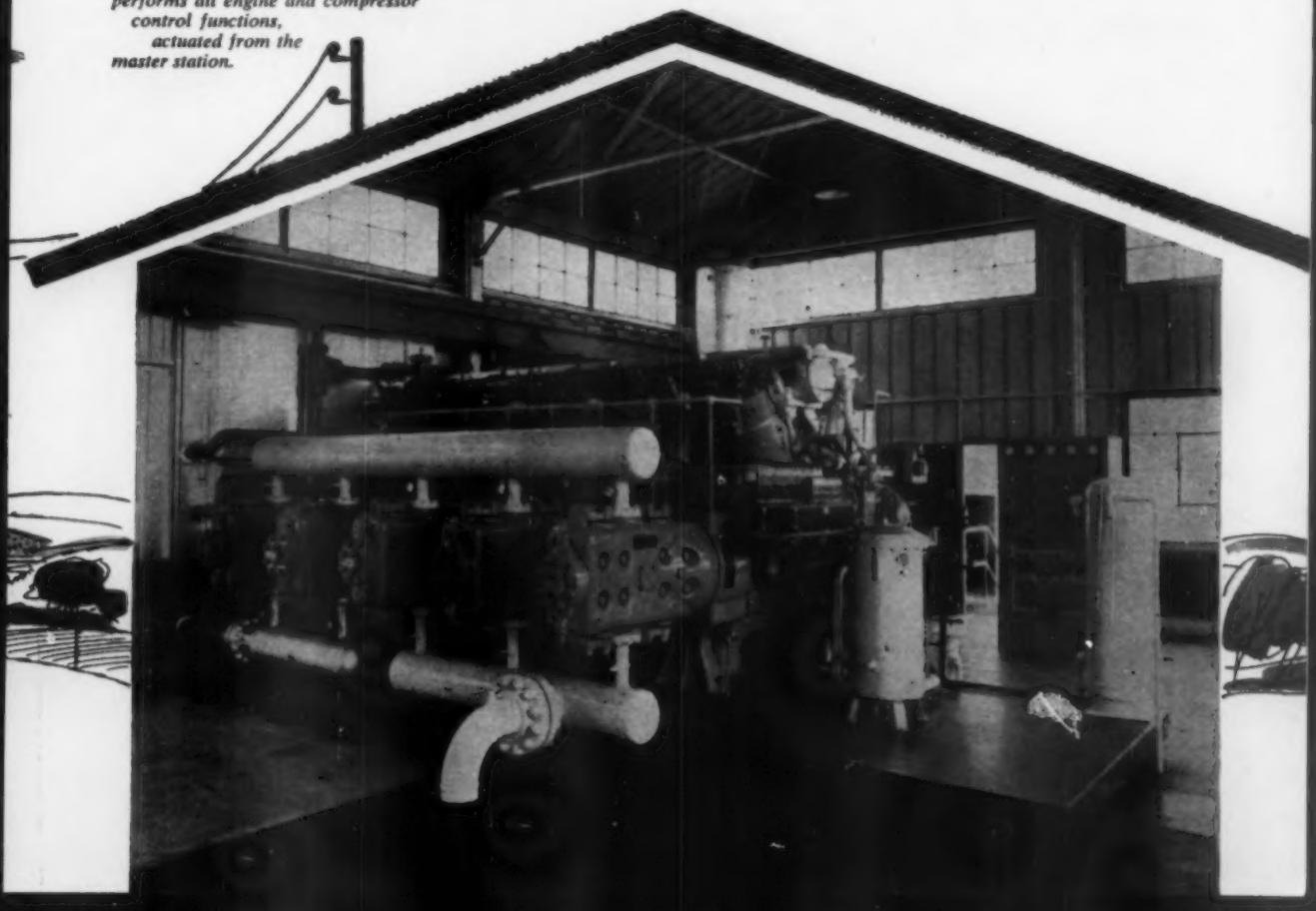
GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE, TURBINE OR MOTOR DRIVEN

Foreground: Cooper-Bessemer GMXD-10 660 hp Packaged Compressor at Columbiana Station. Background: Cooper-Bessemer En-Tronic Control which performs all engine and compressor control functions, actuated from the master station.



"DOES WORK OF TWO DITCHERS HANDLING ALL 3 OF MY JOBS"

Pipeliner Pete Gallatin calls Barber-Greene Model 774 Ditcher "most modern, advanced construction machine...completely new ditching concept"

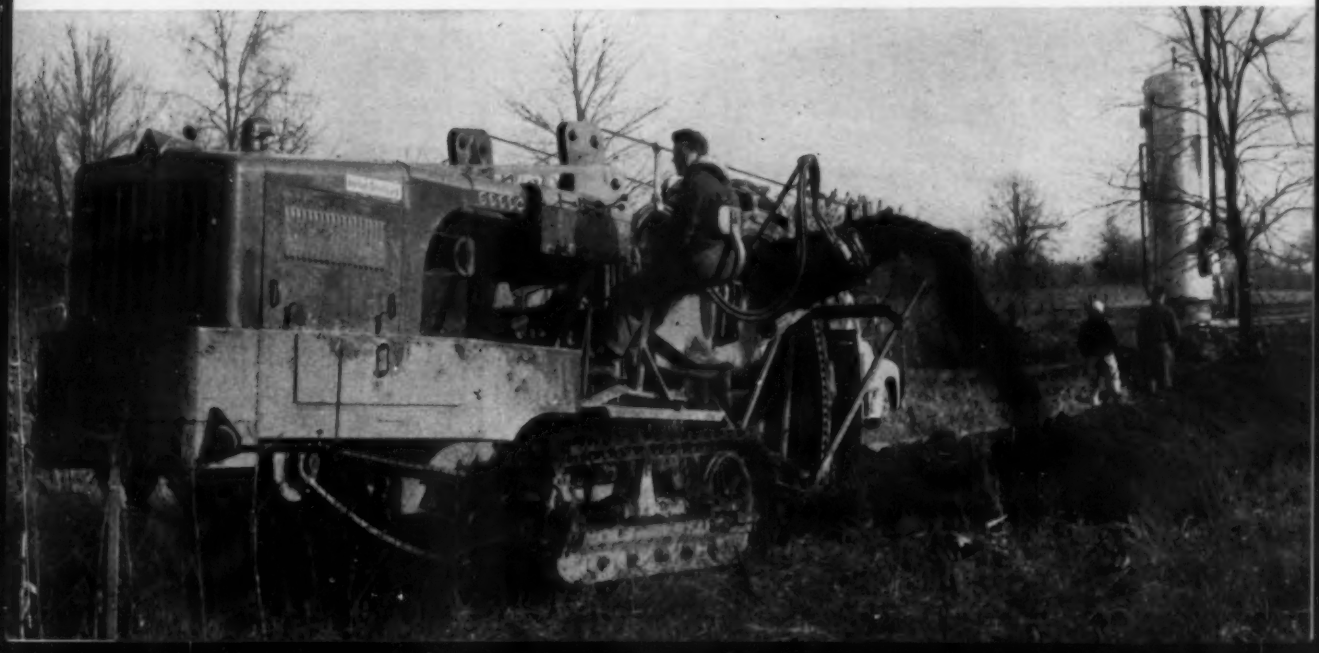
Pipeline construction company president Pete Gallatin knows increasing ditching production by 100% is as easy as changing machines—stepping up to a Model 774 Barber-Greene with 7-ft. wheel —the industry's biggest buy because it outdigs and costs 50% less than any other 7-ft. ditcher.

He reports: "My company handles virtually every phase of pipelining and for five years I used other ditchers. But this Model 774 Barber-Greene opened my eyes from the start—does the work of two same-size ditchers and trenches so fast I can keep all three of my jobs in Michigan and Illinois moving by shuttling it back and forth. It not only gives me 100% more production, but it excavates boulders and rocks far easier than other ditchers I owned. For my money, it's the most modern, advanced construction machine on the market with a completely new concept of digging—not just an alteration to existing equipment."

Exclusive dual-range Hydra-Crowd transmission makes the big difference. Operators dial *instantly* the maximum crowding speed for any ground condition, or reverse *instantly*, too. They select from *infinitely variable* crowding speeds *independent* of wheel and conveyor drive. No four-operation gear shifting. No guessing about gear ranges. No stopping to change speeds.

Check with your Barber-Greene Distributor and see why Hydra-Crowd and these additional features are found exclusively in the only modern ditcher line: Flexible drawbar between chassis and boom; all-hydraulic spoil conveyor independent of wheel speeds; hydraulic controls for greater line-and-grade-holding accuracy; crawler adjusted 10 times faster than those on ordinary ditchers; and automatic electric overload protection.

Barber-Greene 774 has ditched more than 50 miles for Gallatin by being shuttled between Michigan and two Illinois job sites.



Gallatin's 774 is shown digging trench for gathering lines for Marathon Pipeline Co., near Mosherville, Michigan.

Model 772 (shown) is your best buy for the general utility range—cutting widths from 10-24" and to 5' 6" deep. Model 773 varies only in its wider track gauge.

Manufacturer of the only modern ditcher line

Representatives in Principal Cities of the World

Barber-Greene BG

Main Office and Plant AURORA, ILLINOIS, U. S. A.
Plants in DeKalb, Illinois, Detroit, Canada, England, Brazil, Australia

CONVEYORS • LOADERS • DITCHERS • ASPHALT PAVING EQUIPMENT

Transco's 36-in. line goes through the marshes and over the ridge

THE JERSEY "MEADOWS" are in the distance, a no-man's land of muck, mosquitoes, and muskrats. Napp-Grecco laid some 8,500 ft of Bethlehem 36-in. pipe there.

LINE-UP CLAMPS READY, another joint is eased into place. The welded joints were X-rayed and hydrostatically tested.

Here's a pipe-laying job that beats 'em all for sheer orneryness.

Under a $1-million award, Napp-Grecco Co., of Newark, N. J., laid three miles of Transco's new, 36-in. looping line through the notorious New Jersey "meadows," then up and over the 300-ft-high rocky ridge bordering the Hudson River.

For six weeks the contractor's men and equipment slogged through the mucky meadows, at one point laying the pipe 16 ft below mean sea level. Then to the other extreme, drilling, blasting, and clawing their way through solid rock—working slopes so steep they had to anchor their backhoes to heavy tractors to prevent runaways.

To complicate things even more, it was necessary to burrow under a number of highways and, passing through city streets, they had to contend with a maze of underground utilities.

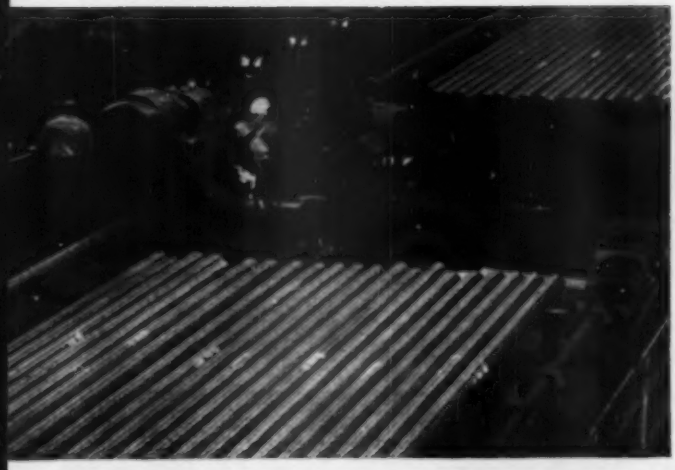
Finally, down the other slope they went, to connect up with dual 24-inchers recently laid across the Hudson River.

The pipe was Bethlehem's, widely used along Transco's 1800-mile-plus looping line from the deep South clear up to the streets of Manhattan.

Why not place *your* order for Bethlehem Line Pipe? It's available in any size you need, right up to 42 inches OD. *And with walls to ¼ in. in all the larger diameters through 42 in.*

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL



ON TOP OF THE RIDGE, in a thickly populated area, the contractor had to thread the joints through a network of sewer, gas, and water pipes. Bethlehem produces expanded pipe with ¾-in. walls in the larger diameters, for use where higher safety factors are required.

BETHLEHEM'S ELECTRIC RESISTANCE-WELD PIPE was used for utility tie-ins all along Transco's main line. It's now available from 5⅝ in. to 16 in. OD in lengths to 60 ft. We also manufacture continuous buttweld pipe up to 4½ in. OD.

BETHLEHEM STEEL

MORE WORK POWER

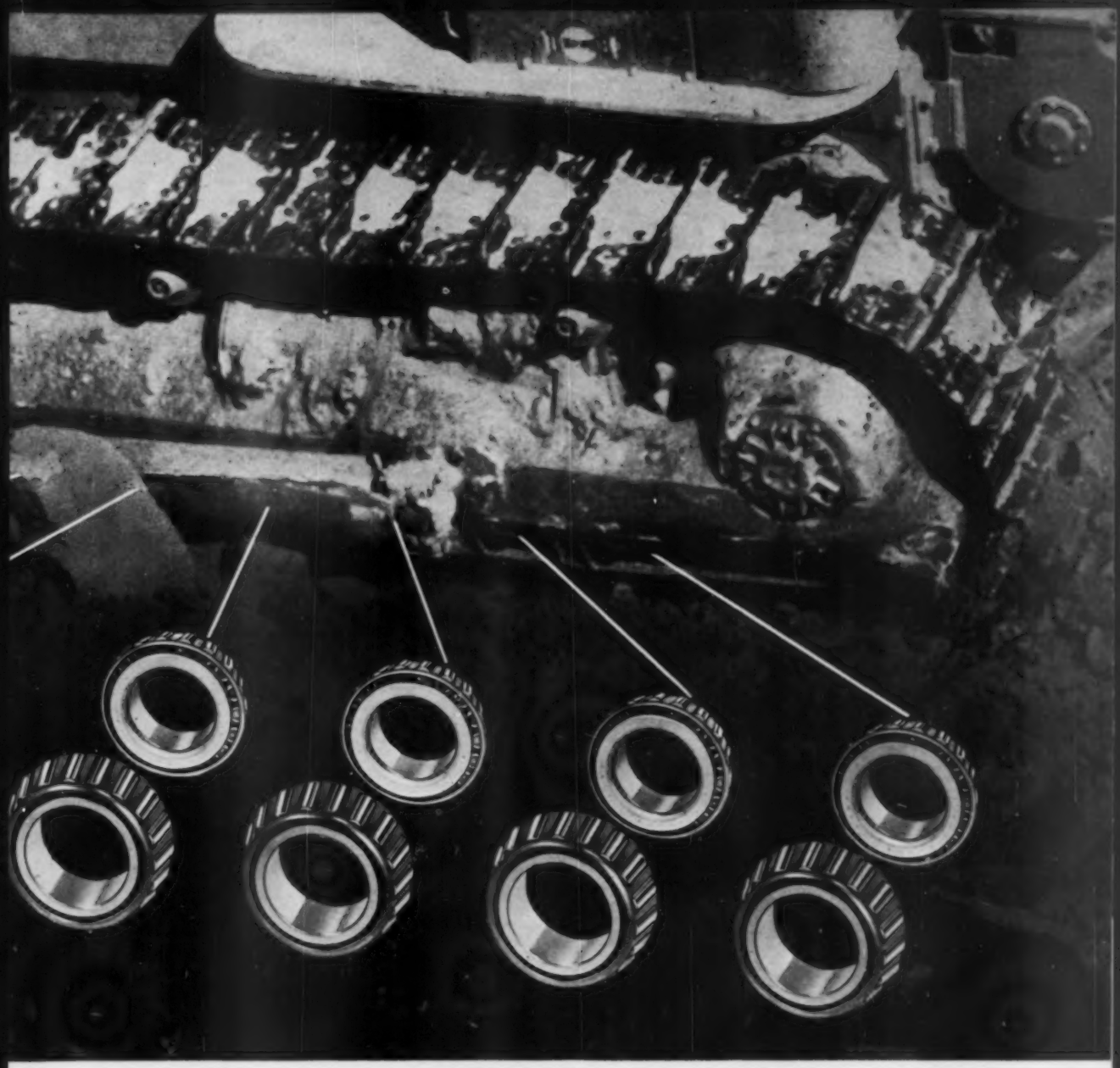
Reduced friction through use of tapered roller bearings in all Allis-Chalmers crawler tractors makes the difference in work power and profit for you!

All Allis-Chalmers crawler tractors roll on tapered roller bearing truck wheels. Most others still use bushings.

Anyone who remembers his roller skating days knows the performance advantages of bearings over bushings. The difference between first and also-ran was in the wheel bearing. This friction-reducing advantage is the reason railroads all over the country have turned to *roller* freight.

The same principle applies to tractors except much more power is being wasted by friction-type plain bushings. It's one of the reasons the 225-hp HD-21, on tapered roller bearings, produces right alongside the biggest tractors you can buy. Can you

move ahead with



PER HORSEPOWER

continue to pay for power that *never* produces—that gets "lost" in old-fashioned bushings?

Your Allis-Chalmers dealer will be glad to discuss this and the many other advantages that keep the HD-21 on the go shift after shift with a minimum of maintenance. Ask about the *toughest track ever built* . . . the *industry's healthiest engine* and *certified permanent lubrication*. Allis-Chalmers, Construction Machinery Division, Milwaukee 1, Wis.

ALLIS-CHALMERS

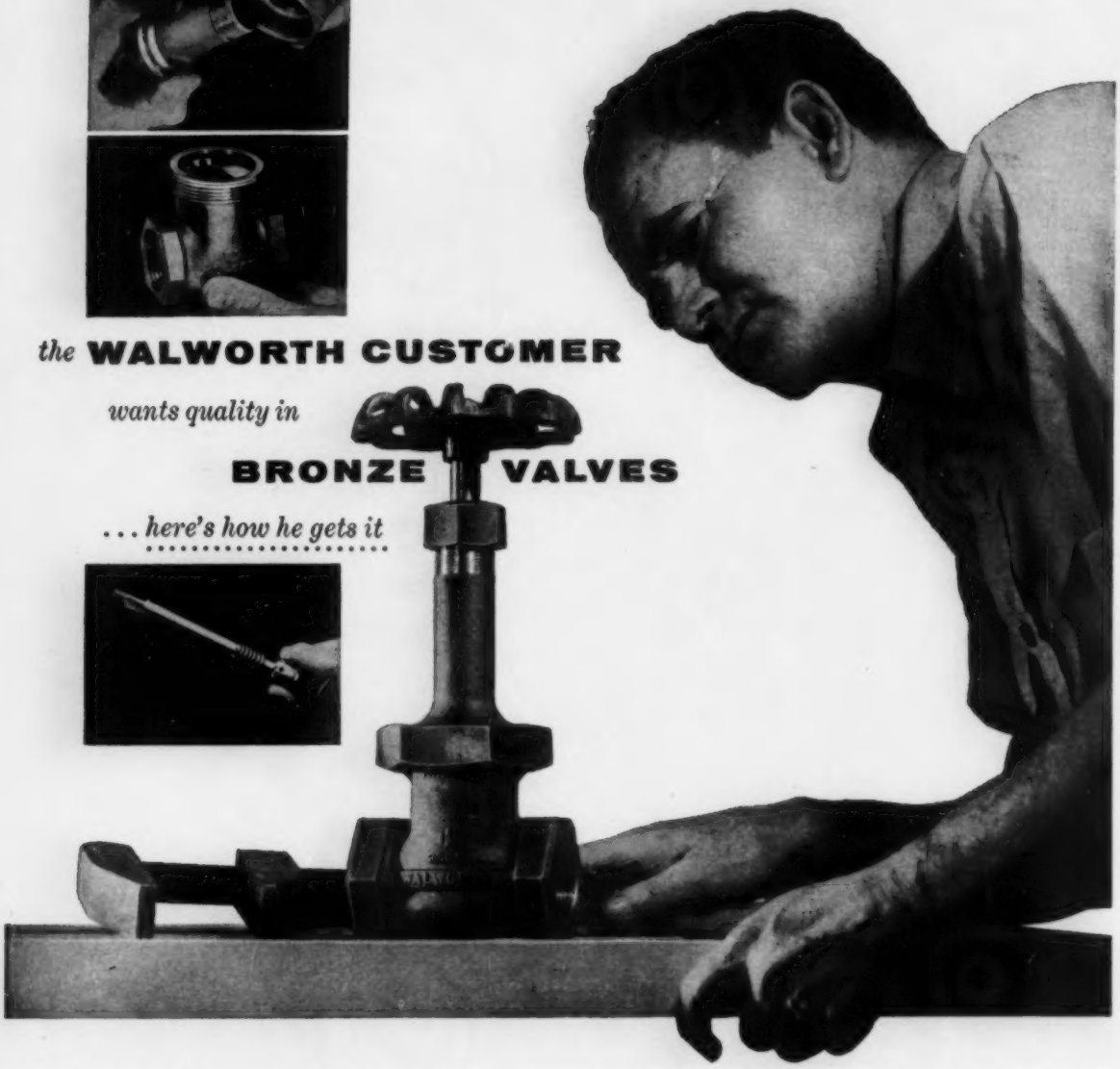
power for a growing world

the **WALWORTH CUSTOMER**

wants quality in

BRONZE VALVES

. . . here's how he gets it



When he needs Bronze Valves, the Walworth Customer grabs a wrench. He wants to *see* the quality. He examines body construction for wall thickness. He looks at stems for length and depth of threads. In Walworth Bronze Valves, the Walworth Customer finds a union body-to-bonnet construction which means easy disassembly. It means no leakage, even after many take-downs and reassemblies. He finds extra-large stems, with extra-long, extra-deep threads. That means protection against wear, and tight, positive shutoffs. With these facts in hand, he buys.

You, too, may be insistent on having your valve facts first-hand, and being certain of long life and minimum maintenance. If those are your buying habits, we'd like you for a Walworth Customer, too. For full information about the complete line of Walworth Bronze Valves and Fittings, ask your Walworth Distributor.

Or write **WALWORTH** *750 Third Avenue, New York 17, N. Y.*

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

WALWORTH SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO. • NOH VALVE & FITTINGS CO. • SOUTHWEST FABRICATING & WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Complete Message Center in one Teletype Machine

A complete message center in a compact cabinet, with a choice of components to best meet your individual needs—that's the story of the Teletype Model 28 automatic send-receive set.

It provides facilities for sending and receiving on message paper or sprocket-fed business forms. In addition, there is a choice of four different tape reader and four different tape punch components—for preparing punched tape and for sending and receiving with tape.

The flexibility of the set is further broadened by a built-in control unit, the "stunt box," which may be equipped for a wide variety of extra features and switching duties—eliminating the need for external apparatus often required for such functions.

The ASR set is a compact, efficient tool to speed communications and cut costly paperwork. Why not investigate what it can do for you?

Typing Tape Punch

Tape Reader

Send-Receive Page Printer

Automatic Send-Receive Set

FREE LITERATURE: Write for Model 28 "Complete Product Line" brochure. Teletype Corp., Dept. 92D, 4100 Fullerton Ave., Chicago 39, Ill.

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SUBSIDIARY OF *Western Electric Company* INC.

PROTECTION
is our business

The finest protection that nature and science, working together, can provide for your pipe lines is found in Nicolet Asbestos Pipe Line Felts.

From Nicolet's mines, through quality controled manufacture, to final shipment for mill wrap or over-the-ditch application, every step is calculated to give you the best in quality, performance and economy.

You can choose either the popular #15 "Standard" or the #8 "Tufbestos" with equal confidence. Both are Tar or Asphalt saturated Asbestos, Glass Reinforced, Perforated or Non-perforated. The #15 "Standard" is also available without Glass Reinforcement.

Or, your requirements may indicate Nicolet "Reflecto" Asbestos Pipe Line Felt. This is a white wrap that is capable of reducing enamel temperatures as much as 30%. It is strong, tough and light weight—a wrap that handles easily and is economical to ship. It has built-in resistance to shock and scuff and is Glass Reinforced and Perforated.

More and more Corrosion Engineers are finding complete satisfaction in Nicolet Pipe Line Felts. Write today for full particulars and samples.

Distributed throughout the United States • District Sales Offices: Ford & Washington Streets, Norristown, Pa.; P.O. Box 777, Hamilton, Ohio

NICOLET INDUSTRIES, INC.

FLORHAM PARK, NEW JERSEY

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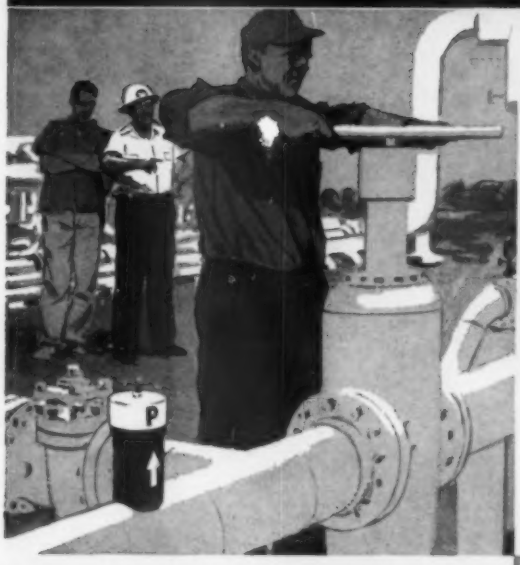
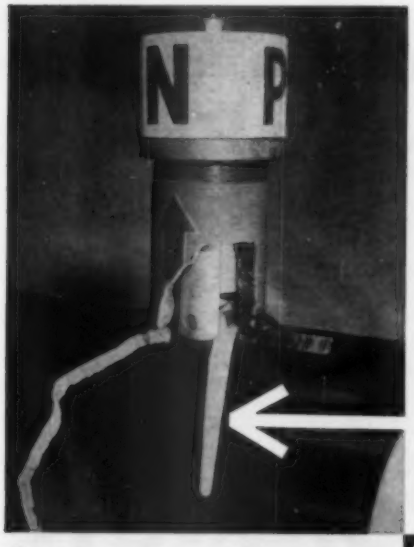
NEWS FROM DOWN THE LINE!



NEW WmSON "PIG-SIG II" CAN BE INSTALLED OR REMOVED UNDER PRESSURE!

❷ "The Pig-Sig II with the Electrical Indicator can signal arrival of pig to pump station operator or start operation of automatic equipment to open and close valves."

❶ "The station operator knows the pig has arrived because the Pig-Sig II visual indicator is in the "passed" position. He no longer needs to wait and listen at the scraper trap."



❹ "This completely new Pig-Sig II uses a standard 2" Thread-O-Ring Nipple. Easily installed under pressure with WmSon Tapping Machines, using a standard drill.
The Pig-Sig II is available with either an electrical or visual signal, extended or regular."

❸ "This new, improved long trigger action detects scrapers even in oversize pipe. Pig-Sig II is excellent for use in metering or calibration."

"Pig-Sig II" Patent applied for

• Write for Bulletin A-199

T.D. Williamson, Inc.

P. O. BOX 40 • TULSA 2, OKLAHOMA

REPRESENTATIVES AROUND THE WORLD

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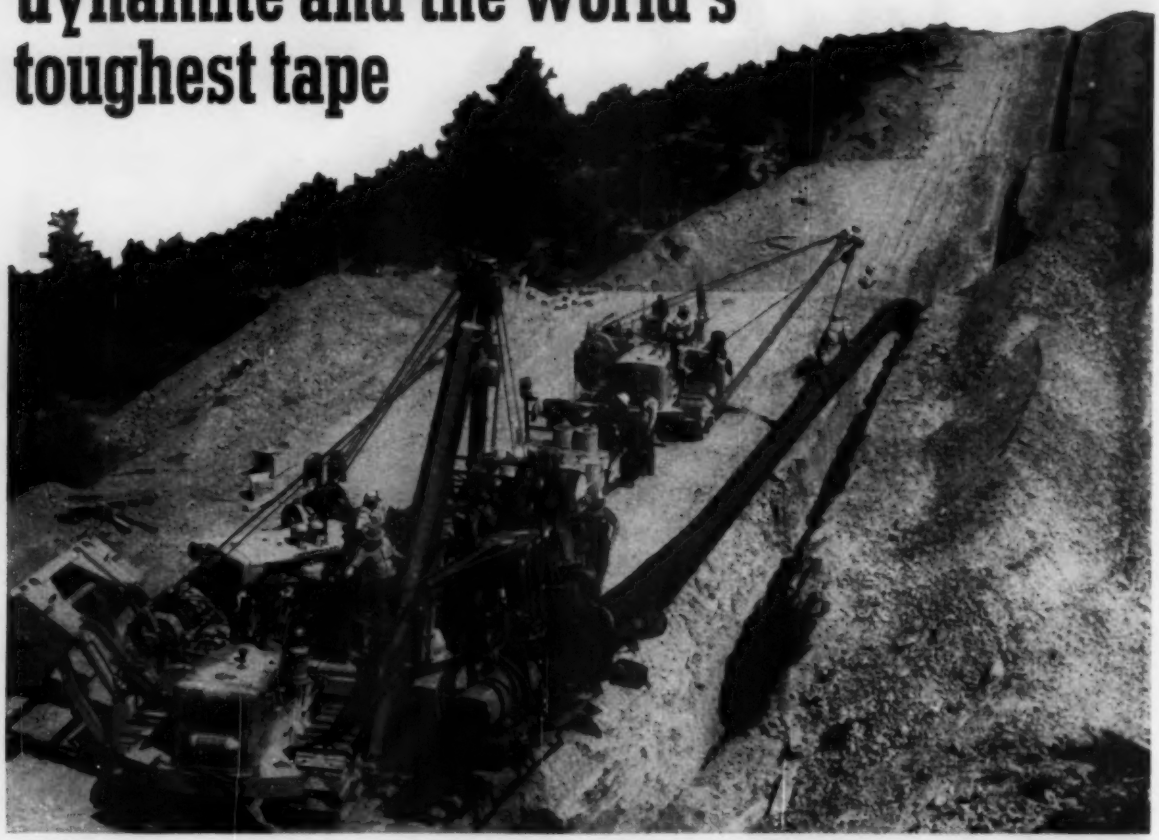
Jobs this rough need mountain climbers, dynamite and the world's toughest tape



New Mandalay line protected by Polyken Extra-Strength #960

Putting in Richfield Oil's Mandalay Line was as mean a job as we've ever seen.

The line runs from sea level to points up to 8,300 feet in the mountains of Southern California, with grades over 40%. In places the trench was blasted out of solid rock. It took rugged crews to put the line in and a rugged tape to protect it.

On the recent big Florida Line and other lines in America, on lines in Canada and in Iran, Polyken has proven itself the most practical and economical protection you can put on a pipe.

Polyken tape pays off in performance—and in the currency of less men, less equipment, greater efficiency, more footage per day during construction. With tensioned-spindle equipment, pipe is cleaned, wrapped and over wrapped in one factory-smooth operation. Tape's ready. No primer, no drying or cooling, no fumes or fire hazard—none of those hot-dope problems.

Before you plan your next job, we'd like to tell you more about Polyken Extra-Strength #960. Call the Polyken distributor nearest you, or write Polyken, 309 West Jackson Blvd., Chicago 6, Illinois.

Polyken Tapes can be applied swiftly, easily, effectively, even under extreme conditions. This mountain-country coating went on with flat-country simplicity. That's why more contractors and pipeline managers are specifying Polyken.

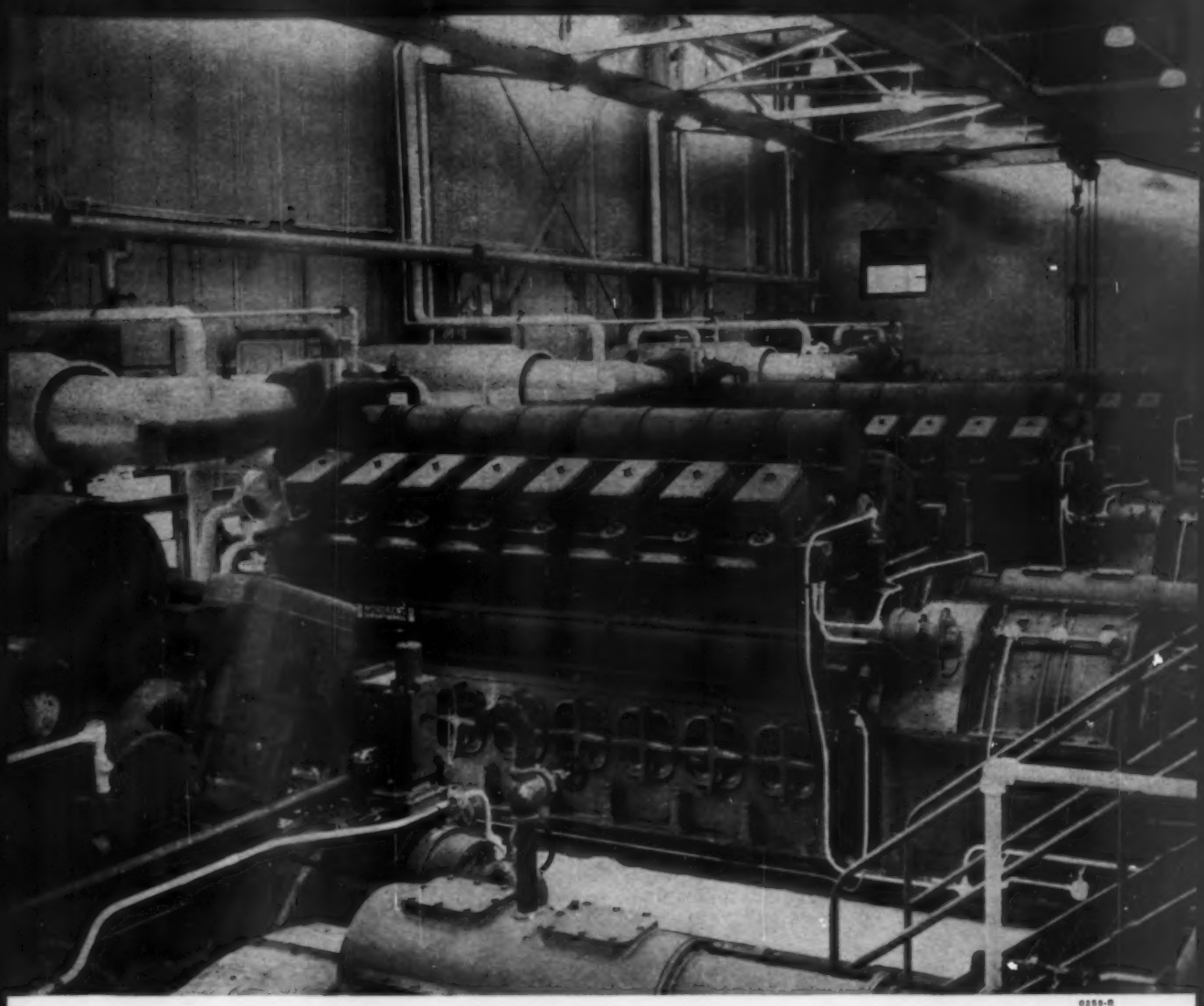
THE MODERN WAY

Polyken®

EXPERIENCED IN PROTECTIVE COATINGS

THE KENDALL COMPANY
Polyken Sales Division

© 1960 The Kendall Company



0259-B

Pipe line engines by Nordberg

Eleven Nordberg *Supairthermal*® spark-ignition gas engines are presently in operation at the second, third and last station along the new Westcoast Transmission Company Ltd. 30" gas pipe line in western Canada. Each of these units consists of a 16-cylinder Nordberg V-type engine, rated 3550 bhp at 500 rpm driving a 24" x 24" centrifugal gas compressor thru a built-in, 10:1 speed increasing gear.

NORDBERG MANUFACTURING COMPANY
MILWAUKEE 1, WISCONSIN

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NEW ORLEANS • NEW YORK • ST. LOUIS • SAN FRANCISCO • TAMPA
WASHINGTON • TORONTO • VANCOUVER • JOHANNESBURG • LONDON • MEXICO D. F.

FIG. 1. Illustrating the application of a control system to an existing pipeline network with a limited number of compressor stations.

System Concepts for AUTOMATIC Pipeline Control

A basic equipment nucleus that is expandable in orderly manner as requirements change contributes to controlled costs

D. E. Dufford, Manager
Applications Engineering
Genesys Corporation

THE PIPELINE INDUSTRY has experienced phenomenal growth in recent years. Predicted further requirements for natural gas and petroleum products to service the increasing population tend to insure a continuance of this growth. However, certain factors, such as increasing government control, spiraling labor and material prices, confront management with the problem of controlling costs. A significant contribution can be made toward increased pipeline profits through the application of systems-engineered controls.

Automatic control systems for existing and new pipelines should have the advantage of a basic equipment nucleus expandable in an orderly manner to complete optimizing control. These systems should not be reworked military or business developments applied to a new program. They should be, instead, systems embodying advanced and tested concepts in control based on the specific requirements of pipeline operation.

Control system cost is kept at a minimum by the use of two key principles in basic design philosophy. First, total equipment requirements are kept low by permitting components to share control functions. Second, by employing an "evolutionary" concept, the control system can be supplied with a basic nucleus of equipment to meet initial requirements. Additional equipment can then be added as desired to meet changing requirements. This enables the basic system to be greatly expanded at relatively small additional cost.

To illustrate this system's adaptability, two gas pipeline situations are depicted in Fig. 1 and 2. Fig. 1 portrays the application of a control system to an existing pipeline network with a limited number of compressor stations. As the need for additional stations arises, it is necessary to integrate these stations and, at the same time, achieve line and network optimization. The adaptability of systems-engineered units enables this to be accomplished efficiently and economically because maximum utilization of existing equipment is accomplished.

Fig. 2 illustrates the application of a digital control system to a new, high-capacity, multi-station pipeline. It is interesting to note that the same basic design philosophy is applied in both the limited and complex situations. Also, the individual sub-systems and system components are similar or identical.

System Design Philosophy

System design requirements are reliability, versatility, and economic efficiency. An acceptable design should fully satisfy these requirements while minimizing personnel and equipment costs. Design versatility will enable the system to be integrated into existing manually operated or semi-automatic systems, with the ultimate objective of a completely automatic integrated control system. Control is implemented by setting compressor or pumping station set points as a function of the changing measured data. These data include pressure, temperature, and flow, as well as new load requirements due to weather, unexpected load conditions, and equipment breakdowns.

Each compressor or pumping station

FIG. 2. Illustrating the application of a digital control system to a new, high-capacity, multi-station pipeline.

can be unmanned and controlled by means of a small slave computer. The main supervisory-control function is performed by a master dispatching control computer. Here, operating conditions of all stations can be established and commanded through a communication system. The basic control system should be compatible with all forms of communication such as microwave, UHF radio, private wire, or leased lines.

The station computer concerns itself with the internal requirements of the station and the communication of information in and out of that station. Periodically, key parameters are indicated to the master computer. Other data relating to the individual station can be received by the master computer upon command. This relieves the master computer of the responsibility for individual station, minor control functions, and data storage problems, while giving the master computer control of key functions.

Design Features

Reliable, safe, efficient operation and service continuity are design features that reduce outage probability to a minimum and provide "fail-safe" operation in the event of malfunctions. These features are typified by:

1. Standby microwave equipment with automatic switchover,
2. Automatic computer self-checking,
3. Echo check of control functions before execution of commands,
4. Automatic operation of affected stations at last set point or at preset values in event of communication link or master computer outage,
5. Immediate indication at dispatching station and maintenance bases of any abnormal condition,
6. Application of well-developed reliability design techniques to system design,
7. Emergency power supplies at critical points in the system.

Basic control functions are provided by the station control equipment and the master dispatching control computer. The station control equipment provides for the following basic operations:

1. Control of prime movers, compressors, or pumps,
2. Control of line valves,
3. Alarm monitoring and notification,
4. Shutdown protection,
5. Station communications,
6. Self-checking features,
7. Logging of specific functions required, especially off-limit data.

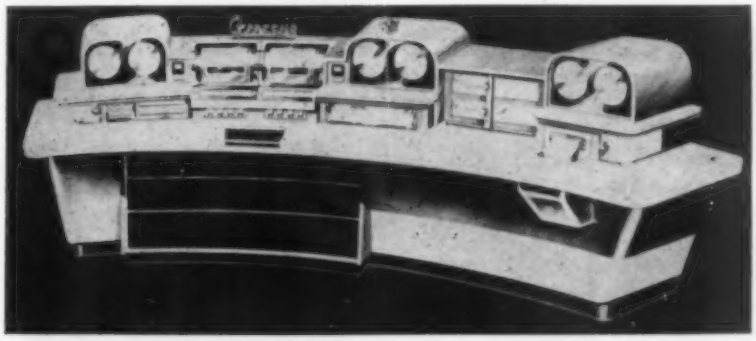
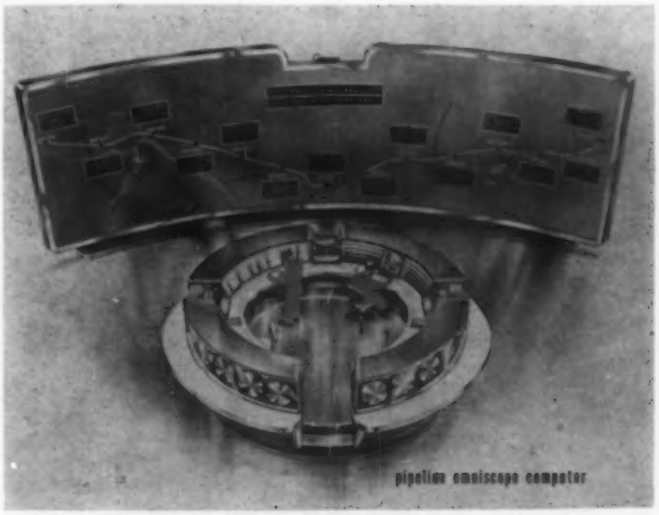


FIG 3. Dispatching control computer for a relatively small existing pipeline system.



F.G. 4. Dispatching control computer for a complex multi-station pipeline system.

The master dispatching control computer has automatic control of the slave stations. In case of emergency or some other need, one or more of the slave stations can be remotely controlled manually. Fig. 3 illustrates a dispatching control computer for a relatively small existing pipeline system.

Fig. 4 shows a more complex installation for a large multi-station line. The master dispatching control system provides for the following basic functions:

1. Complete supervisory control of the entire line through the computer-fed display. This display gives periodic and "on request" data in concise units for direct operator evaluation of any portion, or all the system. This allows manual overriding of the master control computer or its slave stations when necessary. Displays include flow, pressure, station operating conditions, efficiencies, and weather data. Logging of any line variable can be provided upon operator command.

2. Complete control of custody transfer data and computation to the point of billing.

3. Derivation of station and line optimization criteria for future operating situations without interference with present control operations.

4. Production of data in compatible form for accounting or operations analysis computers.

5. Economical expansion of capability to expanded line and system tie-ins.

Digital Telemetering

Digital telemetering provides the most reliable and accurate transmission of intelligence between points in the control system. Information required for alarm scanning, data logging, computation, automatic or manual remote control, and other system functions is transmitted in digital form. Because of the close relationship of telemetering to other system elements, some telemeter functions, such as analog-to-digital conversion, are performed by the system computers.

The end instruments used to measure station variables such as pressure, flow, and temperature, should be proved off-the-shelf components. These instruments are, in general, similar to those presently used in manual-remote station operation. The instruments provide an electrical output voltage that is a function of the measured variable. This voltage value is then transmitted by the telemetering system to the points of data usage.

Both time-division and frequency-division multiplexing are used for efficient transmission of data, reducing the number of channels required. A mercury-wetted, relay-matrix commutator driven by a beam-switching tube counter is used for time sharing of FSK channels. The commutator units are modularized to accommodate 50 functions, expandable by integral multiples of 10 functions. Loss of a single relay results in loss of data for only one function, and not the entire station data. Mercury-wetted relays are used because of their proved high reliability and long operating life. The modular design readily lends itself to expansion of pipeline capacity and control system data capability.

After analog-to-digital conversion, data are transmitted in serial binary form with parity check.

Alarm functions by-pass the analog-to-digital converter and pass through an alarm comparator, which provides binary "one" or "zero" output to indicate "normal" or "off normal" condition.

Decommutation, decoding, storage, display, logging and distribution of

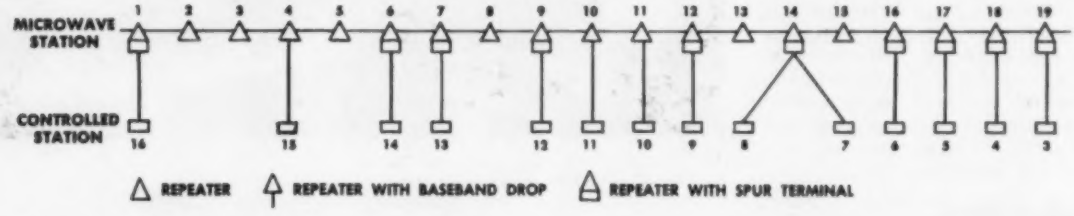
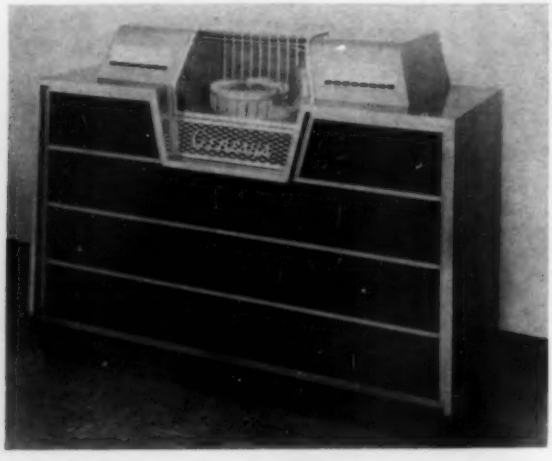

MICROWAVE STATION
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
CONTROLLED STATION
16 15 14 13 12 11 10 9 8 7 6 5 4 3
REPEATER
REPEATER WITH BASEBAND DROP
REPEATER WITH SPUR TERMINAL

FIG. 5. Diagram of an 18-hop microwave backbone system.

FIG. 6. A typical slave station computer.



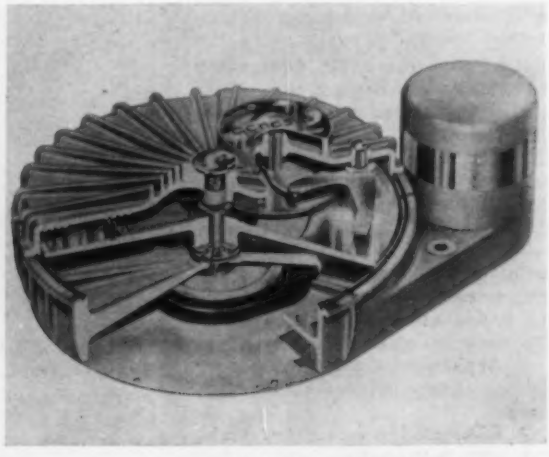


FIG. 7. Memory disc of station computer.

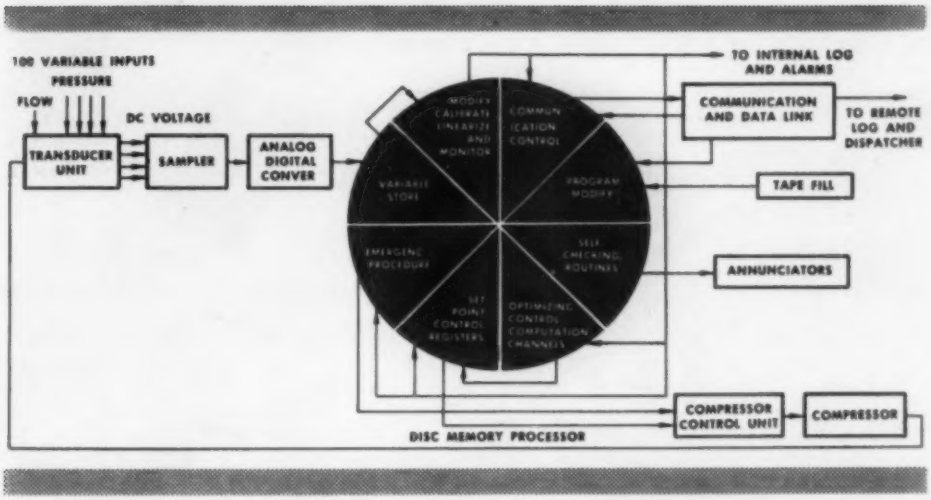


FIG. 8. Block diagram of a station computer.

telemetered data are performed by the computer at the receiving end of a link.

Data Transmission

The basic telemetering system described above is suitable for use with privately owned or leased wire lines, UHF radio or microwave for point-to-point transmission of data. Factors to be considered in selecting the method of transmission are the amount of data to be transmitted, distances, topography and use of, or compatibility with, existing facilities.

A microwave communication system, for example, can provide point-to-point transmission of all data required for instrumentation and control of the pipeline. The microwave system can also provide telephone and teletype communication and trouble indication along the pipeline system. Fig. 5 illustrates an 18-hop microwave backbone system operating in the 6575-6875 mc band. Spur hops to individual stations are used where repeaters cannot be located near stations because of local topography.

One simplex FSK telegraph channel per station is utilized for alarm scanning. A second FSK channel per station can handle, on a time-shared basis, the continuous measurements required for computer entry, display to the dispatcher, and data logging. A third duplex FSK channel per station carries automatic and manual supervisory control, interrogation command, and command verifications signals.

The FSK tone channels may be applied directly to the base-band. In addition, duplex voice channels are provided for communication purposes. The base-band order wire is utilized as a service channel between microwave stations, and a special alarm circuit is provided for the microwave system alarm functions.

Station Computers

Station slave computers are responsible for the following control and data processing functions:

a. Linearizing, scaling, and encoding transducer outputs for data link transmission and limit comparisons

b. Storage of recently accumulated operating variables for use in event of data link outage or station equipment failure

c. Computation of unit set points

d. Periodic self-checking

e. Logging of station and unit functions when required

f. Overall station monitoring

g. Control and collation of digital communications through the data link

h. Miscellaneous data processing functions as necessary

A typical slave station computer is illustrated in Fig. 6. The heart of the station computer is the Unit Memory Processor (UMP), a magnetic disc storage and computing unit. The memory disc, illustrated in cutaway view by Fig. 7, is capable of storing at least 200,000 bits of information on its magnetic surface.

A block diagram of a typical station computer is shown by Fig. 8. Its operation can be summarized as: Instrumented station data are scanned at regular intervals by the telemeter system commutator and converted to digital pulse trains by the analog-to-digital converter. This digital information is placed on the UMP disc to be read out and transmitted via data link to the dispatcher station as required. Certain data are retained in the disc memory for later transmission in the event of temporary data link outage and subsequent interrogation. Certain pre-programmed maintenance information is also retained for use in diagnosing station malfunctions. Continuous UMP operation through periods of primary power failure is provided by means of an auxiliary power supply.

Station computers receive set point commands from the dispatching center. Upon receipt of these commands, the computer performs optimizing calculations, making use of stored compressor or pump performance data. Results of these calculations are fed to the station and unit controllers to establish new operating conditions.

Dispatching Control Computer

The dispatching control computer is the focal point for data collected from all points of the pipeline system and for transmission of control information to the slave stations. The following are among the functions it performs:

a. Receives, stores, and collates telemetered data and manually inserted data, such as anticipated loads, weather conditions, etc.

b. Calculates line efficiency and transmission cost

c. Performs line optimizing calculations and generates set point commands for all stations

d. Self-checks periodically

e. Logs all required data

f. Processes accounting data

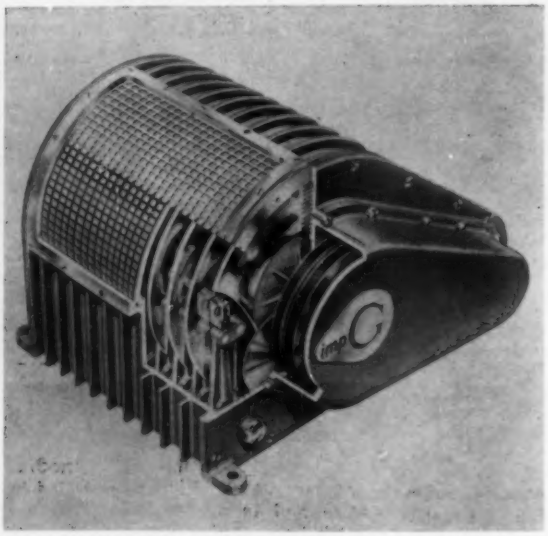
g. Performs special calculations, such as supercompressibility

h. Performs command link operational checks

The important nucleus component of the dispatching control computer is the Infinite Memory Processor (IMP). The IMP is a multiple magnetic disc memory and computing device. The installation for a large, multi-station pipeline will utilize three IMP units, each with a memory capacity of up to 20,000,000 bits. Fig. 9 illustrates the IMP memory unit.

Capability of the dispatching con-

FIG. 9. IMP memory unit, which has a capacity of up to 20,000,000 bits.



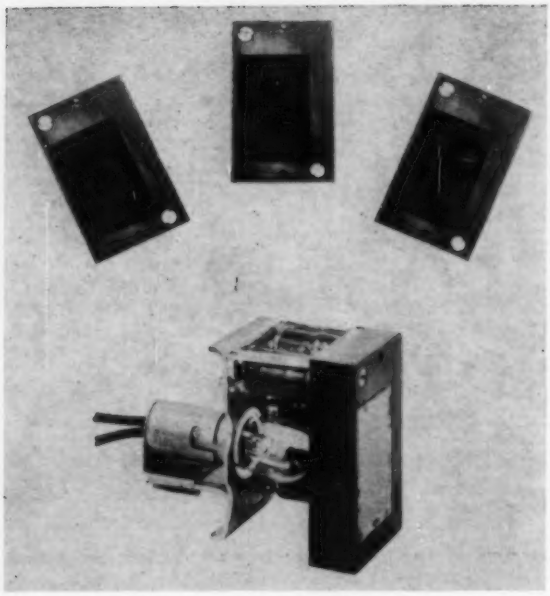


FIG. 10. One type of self-decoding binary readout.

trol computer can be enlarged as the pipeline system is expanded. This growth parallels the acquisition of experience by the pipeline operator and the orderly tie-in of system elements. The dispatcher can assume manual control of any part or all of the system at any time.

The circular console desk contains basic computing equipment, annunciators, logging equipment, communications controls, and manual system control switches and buttons.

The Supervisory Panel

The supervisory panel (Fig. 4) allows the dispatcher to see the entire system at any time in its control perspective. He has available digital displays relating to every station in the system. These displays continuously indicate the values of key variables.

Alarms are indicated by colored lights in the digital readouts and on the board map sector where alarms exist.

The panel has been made practical by self-decoding binary readout, one type of which is illustrated in Fig. 10. This unit converts computer language into numbers, letters, whole English words, or symbols. This simple, reliable, electromechanical unit consists essentially of two etched plates moved relative to each other by a driver mechanism. The relative position of the plates determines the character to be read.

Station Control Panels

The station control panels are important links between the pipeline control system and the basic station equipment, such as set point adjust and unit or station start up or shut down, as commanded by the control system, and will provide the proper sequence of operations to perform these functions.

The station's main control panel system serves as the common element for flow of data to and from individual station control units. The station includes certain indicating instruments and instrumentation transducers for station operating parameters and contains controls for local manual station operation.

Unit control panels serve a similar function with respect to individual units.

D. E. Dufford *holds a BA degree in engineering from Georgia Institute of Technology and an MS degree in applied physics from Harvard University. He has been the responsible application engineer on military and commercial control computers, and has had experience in the operation of several modern large-scale data processors. For five years he was supervisory engineer at the U. S. Naval Air Missile Test Center, Pt. Mugu, with responsibility for installation of the RAYDAC automatic data processor at that facility. Dufford is a member of the Instrument Society of America and the Association of Computing Machinery.*

Conclusions

1. Successful and timely fulfillment of a pipeline control system program requires effective coordination of all phases of the project. This includes definition of project scope, design, material procurement, fabrication, field installation, and field testing. To accomplish these objectives, a qualified staff organization should be established within the systems company.

This project staff should embrace experience in the design and operation of complex systems for use under a variety of environmental conditions. Management is thus assured that the overall control system will be planned and completed successfully, and on time.

2. The same basic design philosophy should be applied in both the limited and complex pipeline situations.

3. Primary system design requirements should be reliability, versatility, and economic efficiency.

4. Small slave computers at individual stations augment most efficiently the master dispatching computer. The main computer is the communication and control focal point.

5. The system design should enable manual takeover at any time of major malfunction or dispatcher discretion.

6. Digital telemetering is the most efficient way of implementing the communications requirements. It is compatible with private or leased wire lines, UHF radio or microwave. ★ ★

Power Bridging for Microwave Stations

Transistorized power inverter converts battery voltage to alternating current, requires little maintenance and minimum power consumption

William E. Freese, *Communications Engineer, Sinclair Pipe Line Company*

ONE of the primary concerns for any communication medium is that of continuity of service. The problem has been attacked from every angle, but emphasis has been on improving the electronic portion, and rightfully it should have been because early day electronic components could not be relied upon for extremely long periods of continuous normal service.

Advancement in component reliability, along with standby equipment that is switched into operating position with little or no elapsed time, have brought radio beam continuity to a point where 99.5 percent is quite common. This last half of one percent was not considered essential a few years ago in face of the high cost to eliminate or materially decrease it, but with increase in use of telemetering, remote control, data processing, and computers, even a short interruption is important.

In order to keep information flowing between send and receive points, it is necessary to have the electronic equipment in proper working order and also have a source of electrical energy available. Battery banks and continuous running engine-generators have been used successfully as continuous power sources, but the initial cost of a large battery bank and the operating cost of a continuous running engine-generator have kept these forms of continuous power from being used by most independent companies. Vibrators also have been used in conjunction with battery banks to supply alternating current where direct current was not practical, such as high voltage supplies, but the vibrators have reeds and arcing contacts that are subject to failure if not maintained regularly.

Transistorized Inverter

Advent of the high power transistor has made possible the transistorized power inverter to convert battery voltage into alternating current similar to the vibrator but requiring practically no maintenance for extended periods. Inverters can be made using vacuum tubes but the maintenance would be higher and the efficiency lower due to the filament power required.

Another advantage of the transistorized unit is that it requires no warm up time and therefore is ready to operate almost instantly when it is turned on, thus allowing the unit to be normally turned off, which saves on power consumption and extends component life while being available within the approximately 25 milliseconds required to sense the power interruption and switch the inverter into the circuit.

The inverter requires only a small battery bank when used in conjunction with a regular engine-generator unit, as the time required to start the engine-generator is less than two minutes even in the coldest weather if it is going to start at all. To allow for a possible failure of the engine-generator to start, the batteries can be sized to carry the load for an hour or two, which would carry the system through most power interruptions or give a man time to reach the station and start the engine-generator. With this type set-up the initial cost is comparable to the 12-hr battery bank, or the continuous power engine-generator, while requiring little maintenance, minimum power consumption, and retaining the ability to supply power for a period of several days or more when necessary.

The charger is a 3-amp normal capacity unit, which is adequate to return 90 percent of the charge to the 40 amp-hr battery within 12 hours after the battery has been used for its maximum period. Actually, it would be a rare occasion for the inverter to be needed longer than 2 minutes at a time, as simultaneously the engine-generator would have to refuse to start and the commercial power outage last more than 2 minutes.

Fortunately, locations having the poorest record of power interruptions are those repeater stations not close to a pump station or other major installation having multiplex equipment, therefore, power requirements are low and the inverter can easily carry the complete load. For the few installations having a poor power record and also having multiplex equipment with its higher power demand, the inverter can be wired to accept only the load of the radio equipment, which would keep the radio beam in operation and lose only the circuits to that one installation.

TABLE 1. Average Power Interruptions per Month Over a 42-Month Period.

STATION	AVERAGE
Hagers Grove	8.8
Lone Jack	7.4
Callao	6.0
Louisburg	6.0
Ramona	4.4
Drumright	4.4
Corder	4.0
Sand Springs	3.9
Kincaid	3.3
LaCygne	3.3
Earlton	3.0
Nelsonville	3.0
Norris	2.7
Morton	2.5
Osage	2.4
Caney	1.7
Table Mound	1.6
East Chicago	1.6
Dallas City	1.6
Adair	1.4
Spring Hill	1.4
Augusta	1.3
Cushing	1.3
El Paso	1.2
Monee	1.0
Independence	1.0
Humboldt	1.0
Flanagan	0.5
Monica	0.5
Key	0.5
Gunn	0.5
Gibbs	0.2
Mazon	0.2
Forest	0.1
Quincy	0.1

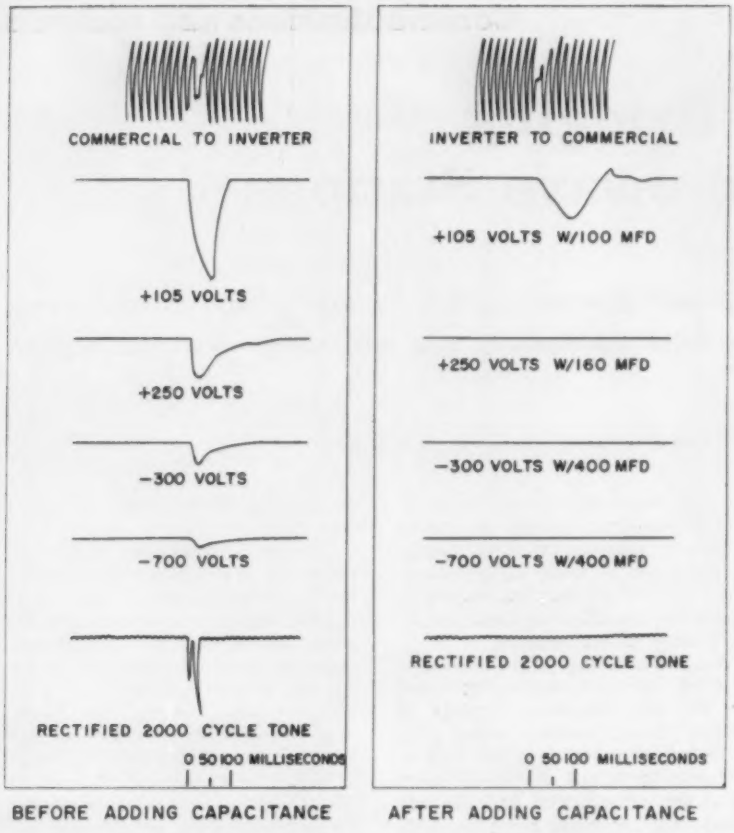


FIG. 1. Oscillograph traces of different voltage before and after adding capacitance.

The average number of power interruptions at 35 stations is shown in Table 1.

Capacitance Added

When the inverter was first tried it was found to be fine for voice circuits, as an interruption of 100 milliseconds is so short that the listener will not miss a single spoken word, but for teletypewriter, telemetering, remote control, or data processing, a short interruption upsets the normal operation. Interruptions were found to be much longer normally than the actual interruption of power to the equipment, due to the time lag for power supplies and equipment using the output of the power supplies to regain normal operation.

To stabilize the output of the power supplies, extra capacitance was added to the output side until the individual outputs remained within usable limits. It was found that some of the voltages were more critical than others, and that the same voltages were more critical at some stations than at others. After checking the inverter operation at four different stations, the values of capacitance were chosen that would be satisfactory at any of the four. Oscillograph traces of the different voltages before and after adding capacitance are shown in Fig. 1.

All recordings were made on a dual pen oscillograph at a chart speed of 125 mm per sec and a full scale deflection of approximately 1 in. Time interval of any interruption could be accurately measured by placing a 2000-cycle tone on a voice channel at a station on one side of the station being tested and receiving the tone at a station on the other side where it was rectified but not filtered, and the d-c voltage put on one pen of the recorder.

Transfer Panels

Tests made up to this time have been with power outages simulated by throwing the breaker on the primary side of the voltage regulator, which did not cause the engine-generator to start up and take over the load. When a complete outage was tried, it was found that the inverter would not bridge the gap entirely because of the action of the engine-generator transfer panel.

One type of transfer panel operates the transfer relay from the generator output, therefore, as the engine shuts down the load is not transferred back to commercial power until the generator output reaches a minimum value for holding in the transfer relay. By so doing the regulator and power supplies are operated to their limits and the inverter is not operated long enough for the power supplies to completely recover, so a short interruption is experienced.

The other type engine-generator transfer panel operates quite fast on shut down so that the inverter has turned on but has not had time to bring the power supplies back to normal when the commercial power returns and the inverter transfer relay operates to complete the transfer back to normal. These two transfer times close

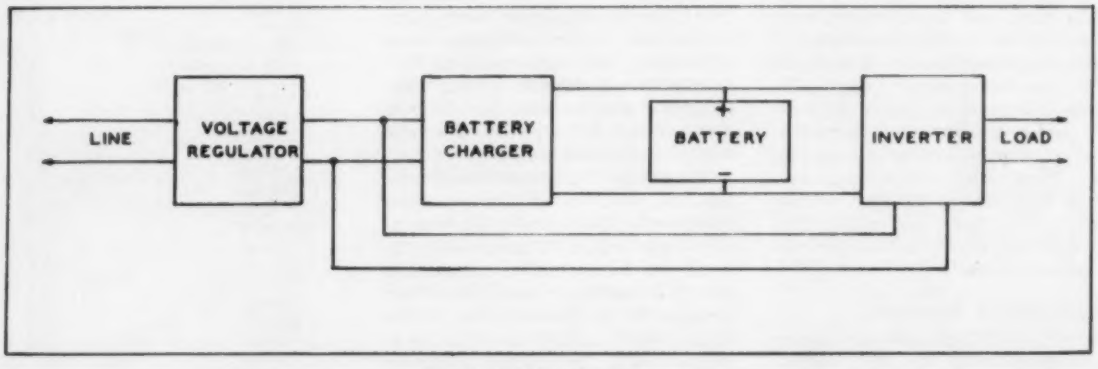


FIG. 2. Block diagram.

Left — Charger panel, with charger and timer relay at top, and inverter with sensing and transfer relay at bottom. Right — Four 6-volt batteries connected to inverter.

together keep the power supplies from building up and an interruption is experienced.

Timer Installed

To remedy the breaks when the engine-generator shuts down, a timer was installed to hold the load on the inverter, once it has assumed the load, until the engine-generator or regular power has been available for 6 to 10 sec. This also allows the voltage regulator time to stabilize, as it may require up to three cycles for the regulator to stabilize after the power returns.

The inverter used for these installations has an unregulated output of 1 kw at 122 v, 60 cycles, square wave, which is stable as long as the input is stable. The input on the units tested is 24 v, although inverters for 36 and 48 v are available, so the input can be selected to be compatible with other equipment.

Square wave output is necessary to gain the high efficiency (85 to 90 percent) possible with transistor inverters, which is desirable when using battery power. Early experiments with the square wave were discouraging because the square wave had a spike on it that caused noise across the baseband, but an improved inverter with the spike almost eliminated proved that the square wave was satisfactory, in fact, the increase in noise on the baseband when on inverter power was less than half a decibel.

122-V Position Found Best

Taps are available on the output transformer of the inverter to give 115, 122, or 130 v, but after trying each tap, the 122-v position proved best. When the battery voltage is high, the transmitting klystron frequency will shift slightly, but as the battery voltage decreases causing the inverter output voltage to drop, the klystron frequency returns to normal and then shifts in the other direction. A voltage regulator was not installed between the inverter and equipment because that would greatly reduce the efficiency of the system operating from batteries.

At three new pump stations the inverters will be installed using the same battery supply for the inverter to power the microwave equipment and the remote control equipment operating directly from the batteries. The inverter will incorporate a 10-minute timer so that after the commercial power has been off for 10 minutes the inverter will be turned off. This would be time enough for the dispatcher to receive the alarm and check telemetered readings, after which the station would be useless anyway until the commercial power returns.

There are many uses for these inverters other than power for microwave stations and their use probably will increase until the equipment is designed to use the battery voltage directly, thereby saving a conversion step. ★ ★

Automation — Communications — Controls

PIEA-PESA Annual Convention

Technical papers covering many phases of automation and electronic controls, as well as normal use of communications as such, will highlight the program of the 32nd annual convention and exhibit of the Petroleum Industry Electrical Association and the Petroleum Electric Supply Association at the Municipal Auditorium in Kansas City, Missouri, April 12, 13, and 14.

Registration will open at 4 p.m. Monday, April 11, in the Exhibit Hall of the Municipal Auditorium.

Delbert R. Wofford is president of PIEA, C. E. Upson vice president, and E. B. Dunn secretary-treasurer.

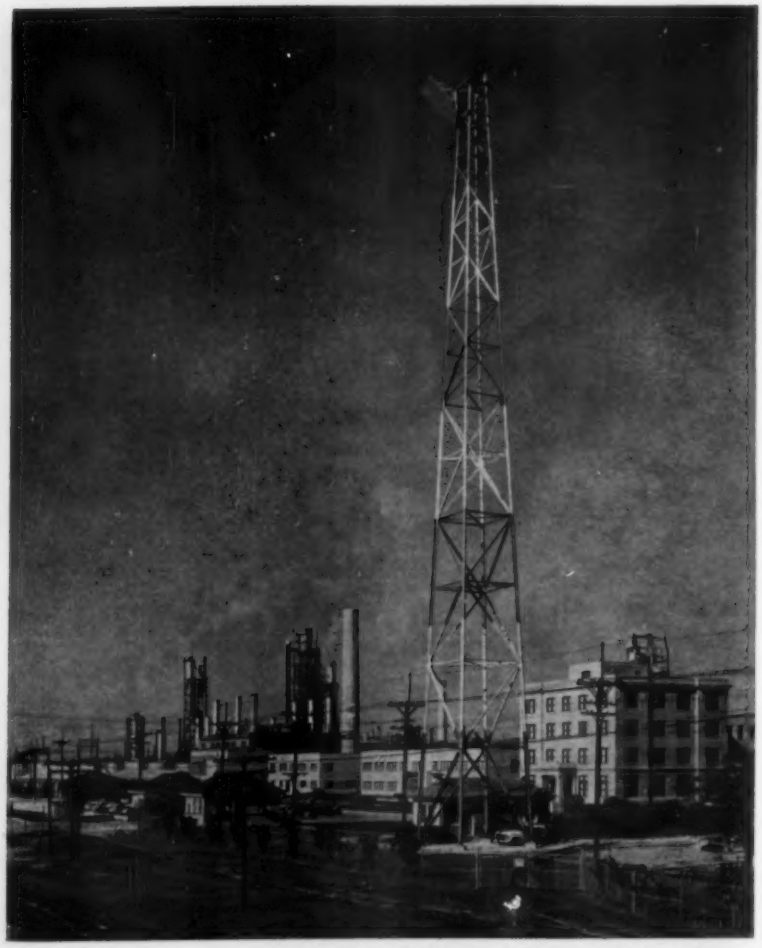
Theil W. Sharpe is president of PESA, John D. Trilsch vice president, and P. S. King executive secretary and treasurer.

Conference chairmen are Fred S. Jones of Platte Pipe Line Company and C. A. Gunn of Copperweld Sales Company.

How Magnolia's Remote Station Controls Work

Two-terminal, 10-repeater microwave system provides communications for control and telemetering between Corsicana and Beaumont

George J. Dorris, Jr., *Senior Electrical Engineer*
Roger G. Smith, *Communications Engineer*
*Magnolia Pipe Line Company**



Self-suporting tower and microwave building installed at the Mobil Oil Refinery, Beaumont.

THE MICROWAVE SYSTEM constructed from Dallas to Beaumont was primarily intended to supply the necessary communications for control and telemetering on Magnolia Pipe Line Company's 20-in. pipeline from Corsicana to the Mobil refinery in Beaumont. Maximum effort was therefore extended toward achieving a high degree of *reliability* for the microwave system while at the same time providing maximum *security* for the individual control channels. In addition to providing for pipeline control and telemetering, the system includes adequate provisions for voice and other communications requirements.

Electronic equipment for this two-terminal, 10-repeater system was manufactured by Motorola, Inc., and employs the new Type MR-20 RF equipment and MC-20 FM multiplex equipment. RF equipment is arranged to provide a system with a full, hot standby for each bay. Waveguide manifold design permits paralleling of up to four bays while using the original antenna system. This will permit economical expansion of the system to include possibly tape-to-tape data transmission, television, frequency diversity, or simply expansion of the system capacity.

Towers and buildings were contracted by Motorola on a turn-key basis with Tower Construction Company supplying the towers and buildings on a sub-contract basis.

At the present time, 11 voice channels and one teletype channel are in service from Dallas to Beaumont and five channels are in service between Corsicana and Dallas. Two voice channels provide voice, control, and telemetering facilities between Corsicana and each of three pump stations. One additional voice channel connects Corsicana and Beaumont. Motorola's order-wire provides a service channel in the 300-3000 cps portion of the microwave baseband.

RF and Multiplex Specifications

Detailed specifications were prepared by Magnolia for the entire microwave system based on their previous microwave experience and upon the A.A.R. specification No. 12-24.

Performance specifications specifically intended for this system included propagation fade margin, and in order to evaluate this margin on an equal basis, a calculation form was presented in the specification. This calculation involved 18 steps and was based on path profile maps provided by Magnolia. The path survey was performed for Magnolia by Television Associates of

*Magnolia Pipe Line Company is an affiliate of Socony Mobil Company, Inc.

Indiana, Inc., using the aerial radar method.

The propagation fade margin that Motorola was required to meet in this system design was 30 db. Acceptance tests showed that all paths met this requirement without modification.

The signal to noise plus crosstalk ratio for the channels on this system was to be 40 db with all channels modulated by 1000 cps tone, with flat-weighting using an F 100 filter, flat from 300 to 3000 cps. With other channels unloaded, this ratio was allowed to be 45 db or better. No discernable intelligible crosstalk was allowed under normal conditions.

Specifications provide for signal to noise of 40 db or better in the poorest SSB channel between Dallas and Corsicana only, with 48 channels of unmodulated FM multiplex in operation. With all FM channels modulated this ratio was to be 45 db or better.

Voice channel specifications were met on the MC-20 multiplex but modification of the grid circuit of the individual channel local oscillator to prevent a parasitic condition from raising the noise level in each channel was necessary.

RF, FM channeling and tone equipment at Corsicana drop and insert station.

Power Supply

U. S. Motors Corporation "Micro Power" units are used at all stations except Dallas and Beaumont. Normal switchover and starting time delays are eliminated by generating all essential station power by a single-phase motor driven alternator. If the normal a-c power source fails, an electrically operated clutch connects the alternator to an engine. The alternator shaft has a heavy flywheel to provide engine cranking force and to stabilize the normal voltage output of the alternator. An additional standby feature is included in the power supply in that failure of the alternator will result in the microwave equipment being connected directly to the normal incoming a-c supply.

FM and Single-Sideband Multiplex Combined

Specifications for this system called for a full channel capacity of 60 voice channels. Motorola was awarded the contract based on their 48 channel, FM multiplex supplemented by 12 single sideband channels of selected frequency allocation, all of which would meet voice channel specifications. Motorola engineers pointed out that passbands of these SSB channels should avoid including frequencies near 16 kc and multiples thereof; 16 kc is the frequency difference between adjacent Motorola FM multiplex channels.

After this system was placed in operation, selective voltmeter measurements indicated that with 16 FM channel loading, the baseband spectrum between Dallas and Corsicana would permit use of SSB multiplex without discriminate selection of channel frequencies. Maximum baseband levels at multiples of 16 kc measured over a 3 kc bandwidth on this portion of the system are 53 db below the 5 mv individual FM multiplex channel level.

In order to gain experience and to prove the feasibility of combining FM and SSB multiplex, Magnolia extended a 3-channel, wireline carrier system from Corsicana to its terminal point in Dallas via the microwave baseband. A modified Setco translator was used in order to locate the three channels above 32 kc. These SSB channels meet voice channel specifications set forth in the contract with Motorola. Translated carrier frequencies of two of the six frequencies used are 48 kc and 64 kc.

Control and Telemetering

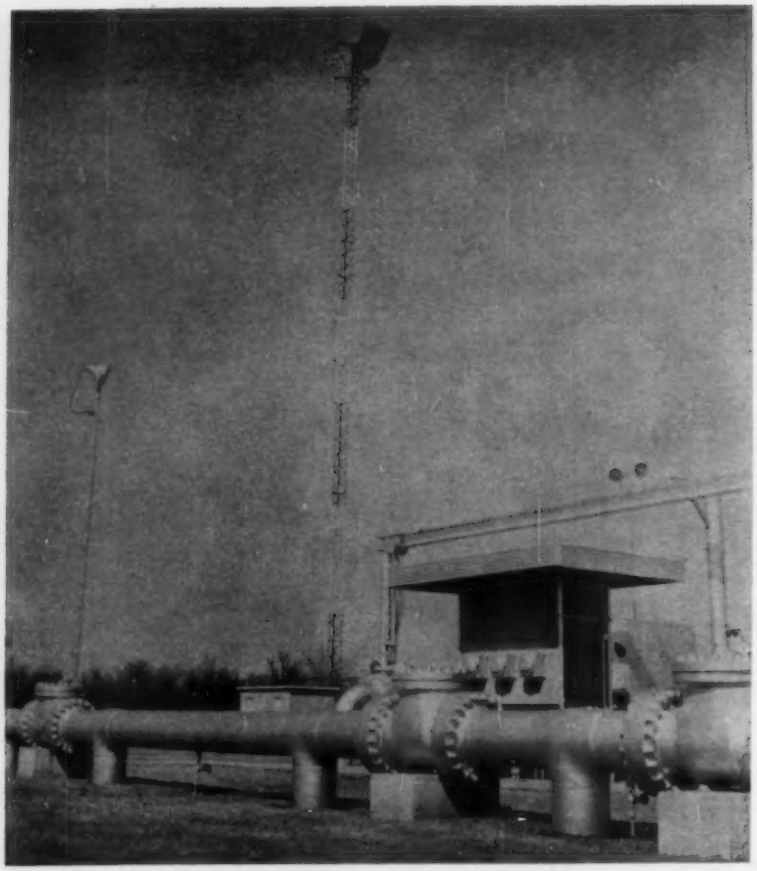
A separate voice channel was provided for control and telemetering to each of the remotely controlled stations: Grapeland, Groveton, and Bragg. The stations are controlled from Corsicana.

It was decided early in the design of the system to require the communication channel to refrain from applying false signals to the supervisory control receivers instead of requiring the supervisory control equipment to incorporate elaborate circuitry to prevent false pulsing. This was accomplished by using a frequency-shift channel with a separate squelch unit. The squelch unit is able to block the erroneous pulses because it operates faster than the frequency-shift channel and is slower to recover after abnormal conditions.

It is interesting to note, however, that field modification was required to lengthen the squelch recovery time in order to tolerate certain fade conditions. The modifications were made during the initial test period and before the stations were placed under remote control. The design objectives were accomplished in that false coding had been blocked before being applied to the control equipment.

The duplex supervisory control channels operate on private, full time voice channels for each station and are therefore mutually independent of multiplex trouble in an adjacent station. Telemetering functions employ the duration-of-time principal and utilize individual, continuously operating frequency-shift tone channels. This results in simplified maintenance and is fully adequate to meet the operating requirements of a complicated, rapidly changing pipeline system.

It is planned in future installations to include a potentiometer in each receiver. This will be used for high speed



Typical installation at Magnolia's Grapeland station.

data logging and possible computer control at a greatly reduced cost from conventional equipment and with all of the complicated and difficult to maintain components concentrated at one location.

The actual supervisory control equipment was manufactured by Westinghouse and employs the pulse code system of transmission. The pulse code system has been used by Magnolia in other control applications and has proved to be extremely reliable and trouble free.

Operational Experience

During the first year of operation this microwave system suffered a total outage time of 32 hours, giving a continuity percentage figure of 99.64 percent. This figure encompasses "system" failures that rendered all end-to-end channels inoperable.

In nearly every "system" failure either the Dallas-Corsicana or the Corsicana-Beaumont portion of the system remained in operation. It should be explained that, although video squelch was not furnished as a feature of this system, isolation of the baseband frequency allottment for the Dallas-Corsicana channels from that baseband spectrum occupied by the Corsicana-Beaumont channels is provided by filtering at Corsicana.

In arriving at the percent continuity figure mentioned, no special consideration was given an extraordinary number of standby power unit starting malfunctions during incoming power failure. These early failures of standby power unit engines to start accounted for a substantial number of total hours of discontinuity. Considerable time was required in the process of trying to determine the exact cause of the starting trouble, since elapsed time between engine running periods seemed to be of importance.

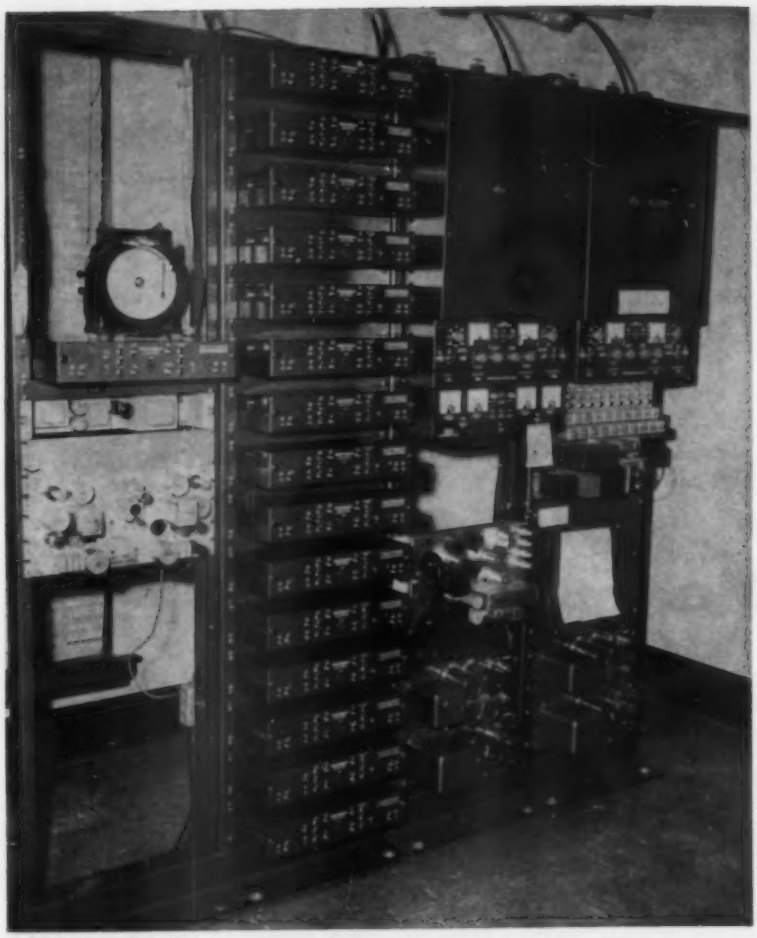
Solenoid valves in fuel lines were specified for this system because of the extra margin of safety offered by their use and we felt that the potential danger in using gaseous fuel in this application justified their remaining in the fuel supply, although it was the power unit manufacturer's recommendation that they be removed. It was theorized by the manufacturer that the solenoid valve could be the source of engine starting difficulties because of its sluggish operation. Movement of the solenoid valve from its original location adjacent to the secondary fuel regulator so that it now occupies a position between the primary regulator and the surge tank did result in an apparent end to the engine starting problems experienced in the early months of operation.

Primary regulators in the LPG fuel system are of the standard type and were originally provided with springs, which allow pressure adjustment in a range above 6 ounces. The regulator manufacturer supplied, upon request, springs that allow adjustment of standard regulators in the range of 4 to 6 ounces. This corresponds to the specified fuel pressure requirements of the engine used in this application.

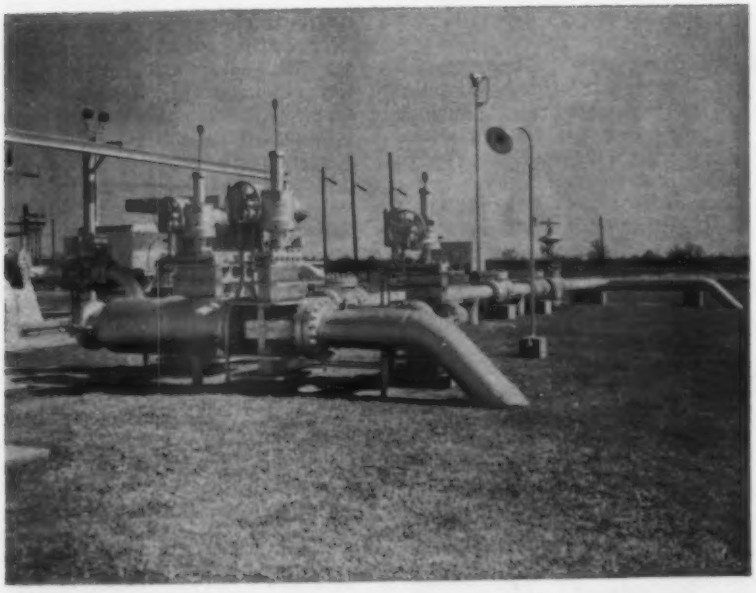
It has been pointed out previously that this system is one with full, hot standby. Bilateral switching is a feature of this arrangement in that either bay equipment, usually known as "main" or "standby," can be in operation at any time if that particular bay is not locked out due to a malfunction. We felt that under such arrangement no switchover should occur during propagation failure and specified accordingly for this system. Early operational experience following installation of equipment included a number of false bay switchovers during short, deep fades. Maintenance personnel discovered that these fades were primarily due to lack of careful adjustment of the sensing circuits throughout the system.

An interesting noise situation developed after the system was placed in operation that involved FM channel noise characterized by the fact that it moves back and forth through the baseband spectrum. This phenomenon was caused by insufficient decoupling of the idle transmitter, as its frequency varies with respect to the active transmitter. However, adjustment of the plunger in the transmitting wave guide filter to give the necessary attenuation took care of this problem.

Component failures have not been excessive. General replacement throughout the system has been necessary only in the case of one particular capacitor and of the original limiting diodes in the receiver AFC units. Silicon rectifiers are used in power supplies for the RF equipment and also for the power supply in each multiplex channel. To date no rectifier failure has been encountered. Forty-four one-tenth watt Klystrons are in continuous service. At this writing none of the original Klystrons has been permanently removed from service. Approximately 50 percent replacement of the other types of vacuum tubes has been made.



RF and channeling equipment at Dallas terminal.



Grapeland station manifold.

No serious trouble other than the engine starting problem already discussed has developed in the case of the rotating machinery. Brush troubles have been few and of minor nature. Malfunction and failure of components inside the automatic transfer panel associated with the emergency power system have also been at a minimum.

One notable addition made to the automatic transfer panel after initial installation was a manual bypass knife switch, although the panel incorporated an automatic bypass feature. Manual bypassing in this manner allows operation of microwave equipment from the incoming power source and, at the same time, removes all voltages from the transfer panel, thereby greatly facilitating any maintenance within the panel housing.

A five point alarm system with transmitters located at 10 stations and detectors at Dallas, Corsicana, and Beaumont has proved satisfactory in that it is reliable in reporting failures; however, some difficulty has been experienced with mechanically produced noises giving uncoded alarm indications from a station when bays are manually switched in that station. Also it was found that certain alarm frequencies, unless placed on the baseband at relatively low levels, would produce tones in the individual FM multiplex channel drops of such magnitude as to be discernible. Similarly, intelligible service channel to FM multiplex receiver cross-talk will be experienced, unless service channel transmit levels are lower than the present 5-mv, FM channel baseband level.

Maintenance Program

The two terminals and 10 repeater stations are maintained by two technicians with assistance when necessary from a supervisor. One technician is based in Beaumont and the other in Corsicana.

System maintenance has included a brief inspection of each installation at least once every three weeks. A very thorough system check has been and will be made biannually. This check consists of making a progressive, station-to-station replacement, adjustment and alignment trip beginning with one terminal and proceeding through the system to the other terminal.

Under the circumstances Magnolia is pleased with the performance of this system and expects to utilize the operational experience gained thus far to good advantage in improving continuity in future systems. Just as pleasing has been the performance of maintenance personnel on this system. The two technicians are Magnolia employees of long standing who have been given some training in microwave. ★ ★ ★

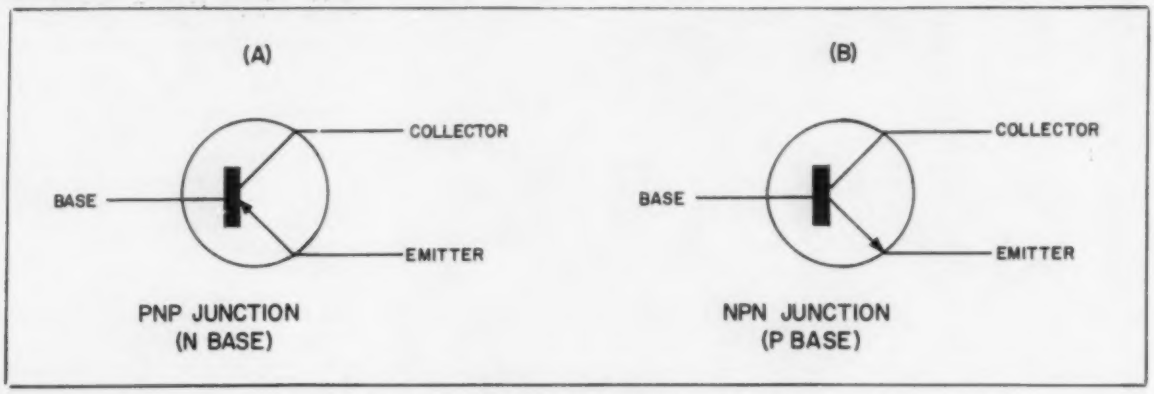


FIG. 1. Junction transistor types schematic representation.

Transistorized Carrier and Multiplex Systems

Part 1: Application of the transistor in circuit design points need for re-evaluation of existing techniques

T. T. Wagner, Jr., *I.T.T.-Kellogg*

SEVERAL recent technological shifts in the development of carrier and multiplex systems have revised equipment parameters in this field considerably. Perhaps the most notable of current trends is application of the transistor in circuit design. This has resulted in transistor circuitry equivalent to that formerly provided by the vacuum tube and also new design objectives made possible primarily through the use of transistors.

The latter opportunity pointed up a need for re-evaluation of existing carrier transmission techniques to determine their practicability in view of transistor possibilities and more stringent field operational requirements. Laboratory study programs proceeded rapidly, production methods kept pace, and as a result completely transistorized carrier and multiplex equipments using advanced design features are available and in field operation.

The following description is provided for the purpose of informing pipeline industry communications personnel concerning the operating characteristics of such equipment. Basic theory is presented initially to assist in further understanding.

Theory and Circuit Data

The advent of the point contact transistor in 1948 as a result of studies by Brattain and Bardeen of the Bell Telephone laboratories indeed caused a stir in the electronic world. Design engineers, aware of vacuum tube limitations, were quick to visualize the possibilities of this new device. After the initial flurry of excitement, however, it became apparent that successful application of this revolutionary discovery would require further study and development.

The initial point contact transistor was an outgrowth of post-war point contact germanium diode research. It was discovered that when a second point contact was placed quite close to the first and properly biased a power gain resulted. Current gain of this type was considerably greater than unity but the underlying theory was not fully understood. Laboratory experimentation appeared the only practical method for design improvement.

Current gain of greater than unity indicated a device capable of negative resistance. This factor plus a high noise figure forecasted a usefulness primarily in high speed switching circuits. It is interesting to note here that the name "transistor" applied to this first semiconductor amplifying device was derived from the words transfer-resistor.

Further theoretical research resulted in the now familiar PNP junction transistor. Initially, as with the point contact rectifiers, a PN junction rectifier was produced. This was a semiconductor device consisting of a single germanium crystal with a junction between a P type region and an N type region. The crystal presented a low resistance with the P region positive with respect to the N region and thusly it rectified. It may readily be seen that power handling capacity was greatly increased because of a larger active area. Both silicon and germanium are used in commercial PN junction rectifiers.

It is well here to present a brief description concerning properties of both P and N types of semiconductor material, since this theory is the basic characteristic of transistor action.

Germanium is used as an example because of its common semiconductor usage. The germanium used in transistors is not absolutely pure and a small part of some selected impurity always exists. These impurities divide the semiconductor into two classes of crystal structure, each having different properties. One class of impurity denotes an N type crystal because this impurity produces many mobile negatively charged electrons. The other class provides a large number of mobile positively charged particles and is known as a P type crystal. The positively charged particles are called holes.

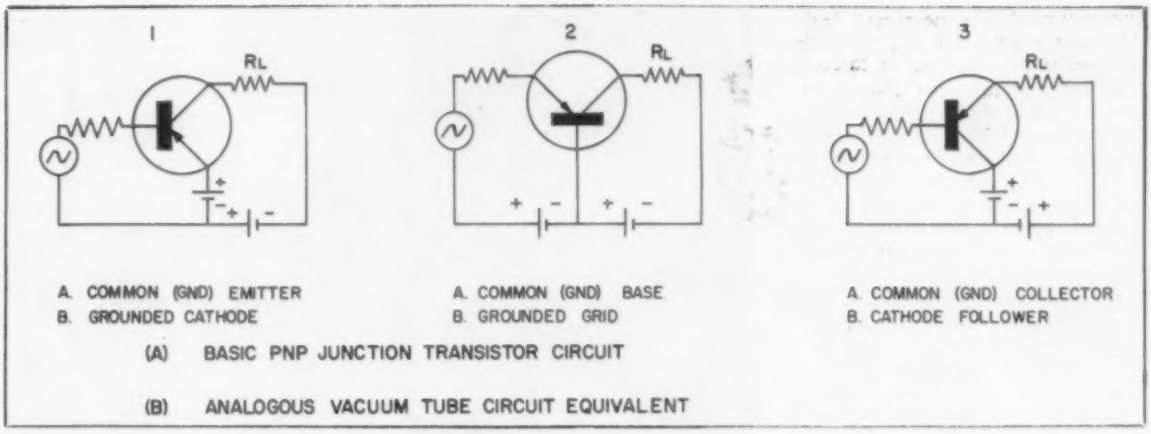


FIG. 2. Basic transistor circuits.

These holes and electrons constitute the two types of current flow within the semiconductor. The hole is considered a fictitious particle, but behaves similarly to a positively charged electron.

Fig. 1 shows the schematic representation of two commonly used junction transistor types. Note that the arrow shows emitter designation. Diagram (A) in this figure shows a PNP variety with the emitter and collector of P type semiconductor and the base of N type. Diagram (B) shows an NPN junction transistor, which is a reversal of the former. The terms emitter, collector, and base, as we shall see later, describe their functions.

For the discussion of basic theory we shall confine our attention to the PNP junction transistor. The operation of a PNP structure is controlled mainly by positively charged holes, with these mobile carriers constituting the current flow having the same direction as conventional current flow. Operational principles of both the PNP and NPN types are exactly the same, so results obtained pertaining to one type will be analagous for the other. A complete solution of current flow patterns in the junction transistor is quite complicated, so this dissertation will necessarily be held within practical limits.

In Fig. 2 the three basic transistor circuits with their vacuum tube equivalents are shown. Schematic diagram number 2 in this figure shows a common base circuit, which shall be used in our description of transistor action. The N region is called the base and the common base circuit therefore provides a reference. The positively biased P region is known as the emitter and injects holes into the base. The other P region is negatively biased and called the collector because it collects holes reaching it from the base.

The flow of holes from the emitter, through the base and to the collector, constitutes transistor action. Positively charged holes provide a link between emitter input and collector output. Electron flow also exists between the base and emitter, but since no link exists with the collector circuit it is of no consequence. The emitter junction is biased in a forward direction with respect to the base, whereas the collector is biased in a reverse direction. Assuming zero emitter current, a small amount of current will still flow in the collector output circuit. This current generally will be in the order of microamperes for germanium and millimicroamperes for silicon. With semiconductor circuitry the collector current cannot be completely cut off such as in a vacuum tube plate circuit with grid at a cutoff bias potential.

If a signal is applied to our emitter circuit causing hole current flow, some of this current will diffuse across the base and enter the collector circuit. This current will add to existing collector current producing an emitter to collector current ratio, which may be as high as 0.99. This ratio is known as the alpha of the transistor. Therefore, we have a small amount of power in the emitter circuit controlling a larger amount of power in the collector circuit, resulting in an amplifying device.

The junction transistor has an alpha of less than unity, however power gain may still be obtained if the load resistance R_L is greater than the input resistance. This is because current entering through a low forward resistance comes out only slightly diminished through the high reverse resistance. The junction transistor is capable of uniform manufacture, has a low noise figure, and will handle considerable power. These and other advantages that follow make it an ideal circuit device for the carrier and multiplex systems, which we shall detail further in this article.

Transistor Application Advantages

The transistor offers so many design and operating advantages that it would be impractical to detail them all here; however, there are several distinct fea-

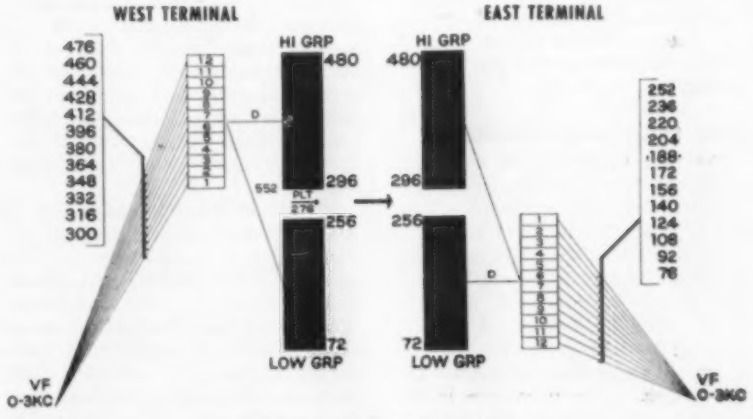


FIG. 3. K24R modulation plan.

tures that need to be mentioned. Probably most important is the extremely low power consumption of junction transistor circuitry. No filament or heater is required as with the conventional vacuum tube. This alone results in a tremendous power saving and also considerably reduces the amount of circuitry. Furthermore, the transistor operates at much lower potentials and current drain for equivalent vacuum tube amplification.

Miniaturization of electronic equipment is always sought and here the transistor proves ideal. In itself it is small and the low potentials and power consumption mentioned above make possible the use of proportionally small ancillary components.

Operating life of equipment components has always been a dominant design factor. This especially applied to vacuum tubes since they were the critical item and a number of tube failures could be expected before component failure. However, the possibility ratio of transistor to component failure is equal or 1:1. Therefore we have improved reliability several orders of magnitude by using the transistor.

Heat required for thermionic emission in a vacuum tube is excellent for that purpose but causes a ventilation problem. Bulky blowers or air conditioning systems were needed whenever large amounts of such equipment were operated. The transistor does not generate any significant amount of heat and thus the ambient temperature remains relatively unaffected. Transistors also will operate over a wide range of ambient temperatures without additional cooling or heating.

Junction transistors also offer an element of shock resistance, which is quite useful in particular applications. Lightweight and rugged construction assist along this line.

A final point worthy of mention is the capability of inversion of properties within a semiconductor. Inverting the P and N structures changes the current flow pattern, a useful feature making possible transistor circuitry beyond vacuum tube capabilities.

K24R Syncroplex System

The K24 Syncroplex is a carrier-multiplex system representative of the advanced transistorized design principles. It is equally adaptable both as a short haul cable carrier and a radio link multiplex. For our description here we shall mainly be concerned with the K24R multiplex version; however, since this flexibility is possible, some of the circuitry may seem unnecessary for one version or the other, but is not removed in the interest of standardization.

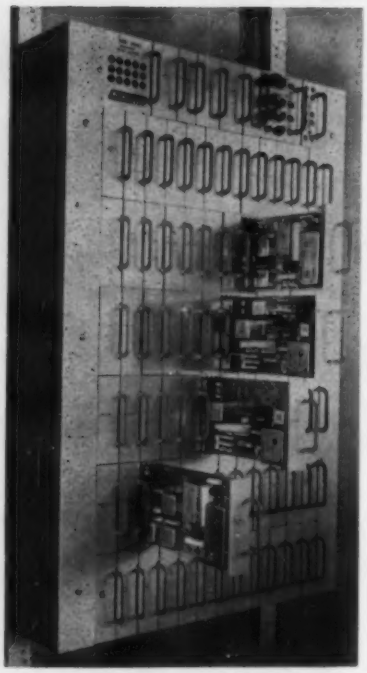


FIG. 4. K24R Syncroplex bay.

Initial studies by I.T.T. laboratories, designer of the K24, indicated that perhaps currently used modulation and transmission techniques did not meet future operational objectives. In addition, economic studies showed the need for a lower cost multiplexing system.

Since many existing systems utilized single sideband suppressed carrier transmission, and had proven operational and economic limitations, it was decided to investigate amplitude modulated double sideband methods. A study was made and DSB AM transmission was found to have decided technical and economic advantages. But a carrier was still present that provided system loading and no useful function. Further development resulted in suppression of this carrier and an unique method of demodulation at the receiver. Therefore, the K24R is an amplitude modulated double sideband suppressed carrier radio multiplex system and is known as Syncroplex for its unique synchronous detection circuitry. A detailed description of the K24R system follows.

The K24R system utilizes amplitude modulated double-sideband suppressed-carrier type of modulation. For our example here we shall use a 24-channel group. Standard group modulation methods are used to expand the system to a total of 96 channels. The channels for each direction are spaced at 16 kc intervals throughout the whole range of the spectrum used (64-480 kc). The West-East direction of transmission frequencies are 8 kc higher than the East-West frequencies; and since each channel occupies less than 8 kc of the spectrum, the channels frequencies interleave, and the possibility of near end crosstalk is nearly eliminated.

The system uses single and group modulation methods to translate voice frequencies to carrier line frequencies and to re-translate the carrier frequencies back to voice frequencies. As Fig. 3 shows, all channels are modulated directly to the high group frequencies at the transmitting terminal. One group of 12 channels is applied directly to the line (after amplification) and the other is group modulated down to the low group frequencies and then applied to the line. At the receiving terminal, the high group is group modulated to the low group line frequencies before demodulation to voice frequencies.

No crosstalk reducing devices. The K24R terminals in themselves will provide high quality circuits without the use of compandors or similar noise crosstalk-reducing devices. For those cases where the radio link has non-linearities or excessive noise, a compandor-like device, called a sonad, is added to the disturbed channel. The sonad adds approximately 15 db loss to the transmission path, when the channel is idle, thereby reducing the disturbing effects of the interfering tone or noise to acceptable limits. The sonad subassembly plugs into the voice frequency terminating unit and may be added when channel noise and crosstalk dictate.

The K24R terminals are completely transistorized and as a result require only a small amount of power. The average total power consumption of a complete 24-channel terminal is approximately 100 watts. Minus 48 volt d-c is the only power voltage required.

Compact and flexible. The K24R system, shown in Fig. 4, is compact and flexible. A 24-channel terminal including all signaling units, carrier supplies, common equipment, and sonad subassemblies (when required) occupies 31½ in. of rack space on 19-in. equipment rack. Such miniaturization makes it possible to mount 96 channels on one 11-ft 6-in. bay. The components of each unit mount on an etched wired board that plugs into the terminal shelf. Hence, systems may be partially equipped initially and channels added at a later date as required. The signaling circuit is a separate unit, making it possible to arrange the signaling for each channel on an individual basis. All external connections are made at two terminal blocks on the front of the shelf. No other shelf wiring is required when the system is installed.

To be continued in an early issue

Although considerable rock is being encountered, the ditching machine is still playing an important role. Here two are being used in tandem. First machine is stripping ahead while second machine makes the ditch wider and deeper. Both have crumming shoes and the back machine is equipped with slopers.

Transwestern Ahead of Schedule Despite Adverse Weather

Year's major gas transmission project scheduled for July completion. Winter construction magnifies problems

Frank H. Love, *Editor*

ADVERSE WEATHER CONDITIONS, consisting of snow, mud, and high winds, have caused personal inconvenience to workmen, but not materially slowed overall construction progress on Transwestern Pipeline Company's 1800-mile plus gas transmission system to the West Coast.

Completion of the project, major one of 1960, is now scheduled for July, well ahead of the original target date. Some spreads began work in late November, others in December.

Recently the writer visited most of the spreads between Texas and the California-Arizona border to learn first hand what problems were being encountered and the methods used to solve them. Obviously, a pipeline of this length traverses many types of terrain, altitudes vary greatly, and during winter construction there is a wide variety of weather conditions from the heat of the desert to below freezing temperatures in the mountains. Some of the new methods observed are the answers to problems created by weather and terrain, others are natural developments resulting from normal and continued progress in pipeline construction procedures.

Gulf Interstate Company engineered the system and is acting as agent for Transwestern during construction. The line is being laid by five contractors: H. C. Price Company, Houston Contracting Company, R. H. Fulton and Company, Sloehan Pipeline Construction Company, and Western Pipe Line, Inc. Division managers for Gulf Interstate are: Charles Novak, Odessa, Texas; James Jolly, Roswell, New Mexico; Gerry Rushing, Pampa, Texas; Charles Landers, Albuquerque, New Mexico; and Herb Goyan, Flagstaff, Arizona.

Some general facts about the pipeline are these:

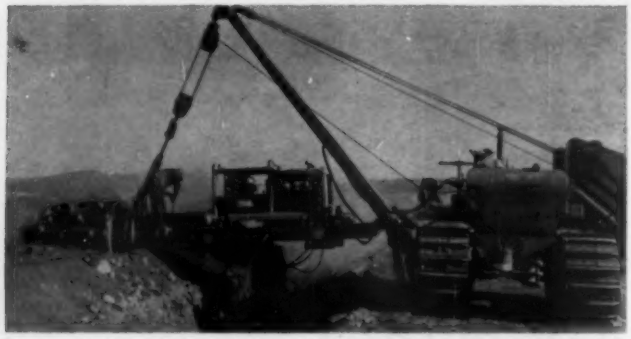
The main line is 30 in. from a point near Roswell, New Mexico, to the Arizona-California border near Needles, California. Feeding into this line is a Southwest Texas 20 and 24-in. lateral from the Puckett field, Pecos County. Also feeding into Roswell is a 24-in. line from the Panhandle area of Texas and Oklahoma. At several points along the route of both smaller laterals are being laid to connect producing areas.

At Needles, Transwestern will deliver into a pipeline now under construction by Pacific Lighting Gas Supply Company for distribution in Southern California by its sister companies, Southern California Gas Company and Southern Counties Gas Company.

Pipe. The 30-in. and 24-in. pipe is Grade X-56, the relatively recent API classification that has a minimum yield strength of 56,000 psi and minimum ultimate strength of 74,000 psi. This grade was first used on a portion of the Gulf Interstate Gas Company system (now Columbia Gulf) with success. Because of its high carbon content it approaches the upper limits of weldability and when first used there were some questions regarding welding procedures, but these were resolved satisfactorily by experience gained at that time.

Welding. Welding of the pipe on the Transwestern system has passed the

Pan scrapers are being used effectively to haul dirt for backfill around pipe to prevent damage to coatings in areas consisting entirely of rock. In some instances dirt had to be hauled two miles.



Ditch padder removes rocks from spoil bank in rocky areas to provide backfill that won't damage coating.

A different kind of overhead bridge. Line will be carried on these trestle bents and truss piers, consisting of pipe driven into ground and braced by cross members. This picture was taken of the Rio Grande crossing near Belen, New Mexico. Two crossings of the Canadian River in the Texas Panhandle will be made on the same design.

Preheaters, a new tool, used to heat pipe ends prior to welding. Pipe is heated to 150 F to allow for cooling to 113 F, the desired temperature at time of welding.

most rigid tests satisfactorily. Four passes are being made in this manner: Stringer bead with Fleetweld 85 rod; hot pass and filler — Fleetweld 5; and cap bead — Fleetweld 85.

Welds are being X-rayed and as many run as practicable without delaying the contractor's pipe gang. This totals about 30 percent of all welds made. As a departure from usual practice, the engineering company acting as agent for Transwestern is X-raying all tie-in welds with its own technicians and equipment. Other welds are inspected by an independent X-ray company acting for the contractor.

Firing line welding is being employed throughout, with tie-ins made every 4000 to 6000 ft.

Coating and wrapping. Coal tar enamel is being field applied to a minimum thickness of 3/32 in., except for gathering lines and some laterals, which are being yard coated. For a distance of 25 miles downstream from each compressor station hotline coating is applied and wrapped with an asphalt impregnated felt. Intermediate enamel is used elsewhere and wrapped with glass fiber and kraft paper.

Cover in good soil is 30 in., in solid rock 24 in.

Main line valves are being spaced approximately every 17 miles.

Testing is by sections between main line valves, with scrapers being run and the line tested with gas.

Gas Supply

Gas supply for the system will come from fields in Southwest Texas and Oklahoma-Texas Panhandle areas. In Southwest Texas the line originates at a carbon dioxide and hydrogen sulfide extraction plant in the Puckett field. This plant is a story in itself, being the first United States installation to use an Italian patented method known as the Giammarco-Vetrocoke process. The plant was designed and constructed under license by Brown & Root, Inc., for Transwestern, and will treat 180,000,000 cu ft of gas daily at a pressure of 1050 psig.

Gas from the Puckett field contains 28 percent carbon dioxide and up to 0.2 percent hydrogen sulfide, which must be treated to produce a pipeline sales gas essentially free of hydrogen sulfide and containing less than 2 percent carbon dioxide. The gathering system to feed the plant consists of 17 miles of 4 to 12-in. pipe.

Between Fort Stockton and Carlsbad 61 miles of 20-in. and 76 miles of 24-in. are being laid. A. J. Slovack is superintendent for the contractor, Houston Contracting Company. For

the first 20 miles out of Fort Stockton terrain was somewhat rocky and shooting was neeessary throughout. The next 30 miles could be machine ditched, then shooting was required in spots on into Carlsbad. Generally, the terrain was rolling, grazing land, with scattered brush on the surface but underlain with rock in many places.

At the time of our visit weather had not been a major factor in deterring coating on this spread; 62 miles of 20-in. had been coated in 29 days, with only five days lost because of weather.

The 20-in. pipe was Grade X-52 with a wall thickness of 0.281 in., and the 24-in. X-56 with a wall thickness of 0.312 in.

Both sizes of pipe were double-jointed on this section. Single joints of 20-in. pipe were received in 48-ft lengths and 24-in. pipe in 40-ft lengths.

Between Carlsbad and Roswell the Houston spread under M. L. Thompson encountered soil that necessitated ripping, drilling, and blasting, as well as some sandy enough that slopers were used to minimize ditch caving. In this section is the Pecos Valley, whose east slope is mostly caliche soil. In the valley were found many smooth round boulders from 12 to 18 in. in diameter. These were 3 to 4 ft beneath the surface and usually the ditching machine would bring them up, but when skipped backhoes were employed to remove them from the ditch.

The 24-in. line from the Panhandle is being laid by Houston Contracting and R. H. Fulton and Company. This is divided into 166 miles from Roswell to Dawn, Texas, by Houston, and 105 miles from Dawn to Canadian by Fulton. Truman Clayton is superintendent for Fulton on this work.

Fulton also is installing some 200 miles of 10, 12, and 16-in. gathering lines in the Texas-Oklahoma Panhandle, where H. A. "Tobe" Veach is pushing the job.

Sheehan Pipe Line Construction Company has been able to make fair progress on approximately 300 miles of 4, 6, and 8-in. gathering lines in West Texas, Oklahoma, and New Mexico, but this contractor has been plagued with more cold weather than any of the others. Two offices have been established: At Higgins, Texas, where J. W. Brown is superintendent; and at Monahans, Texas, under supervision of Boyd Douglas.

Sheehan is laying the gathering systems in the Worsham, McKee, Crawar, South Kermit, Bell Lake, Crawford, and Atoka fields. All pipe is yard coated.

A ripper in action. This is a much used piece of equipment as rocky formations are frequently encountered. It is also used to rip ahead of ditcher when ground is frozen.

Two of the widest river crossings on the system will be of the Canadian on the gathering system in the Texas Panhandle. One of the crossings will be 6120 ft wide, the other 5040 ft, because of the wide flood plain. They are single 24-in. lines supported on bents — piling made of pipe sunk vertically into the ground and connected by pipe cross members.

Western Pipe Line, Inc., is laying 100 miles of 10, 12, and 16-in. laterals to tie-in West Texas and New Mexico production to the 20 and 24-in. feeder lines. A 10-in. line is connecting the Worsham field to the main 24-in. feeder line about 7 miles south of Pyote, Texas. The McKee and Crawar fields, on the Crane and Ward county lines southeast of Monahans, also are tied into this lateral, which extends to the Sid Richardson gasoline plant northeast of Kermit and then enters the nearby Keystone compressor station. From the station a 16-in. line goes west about 17 miles to connect with the main 24-in. feeder line. The contractor later will lay 27 miles of 10-in. to Monument, New Mexico, from Warren Petroleum Corporation's plant near Hobbs.

The 10-in. pipe is X-42 with 0.279-in. wall, and the 16-in. X-46 with 0.250-in. wall.

To effect a better bond of primer to pipe one contractor is running a defroster ahead of the cleaning and priming machine when the temperature is extremely cold. Equipment encircles pipe and is cradled by sideboom tractor. Fuel tank on top supplies two jets that surround pipe with flames.

Special Construction in Sand

Most of the Western Pipe Line section was laid in deep sand, which necessitated a departure from customary construction practice. Because of the danger of sloughing ditch, pipe was welded ahead of ditching. Sections of approximately 3000 ft were welded before the ditch was cut, and the pipe was then lowered and backfilled immediately.

C. L. Siewert, general superintendent, and Clint Schell, spread superintendent, are in charge for Western.

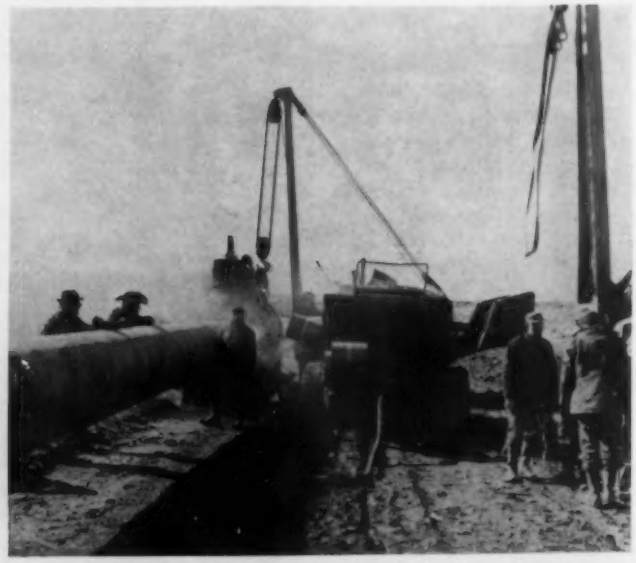
Rock a Problem Here

To the west of Roswell, toward Corona, New Mexico, still a part of M. L. Thompson's Houston Contracting spread, was encountered one of the most extensive stretches of rock on the entire system. Between Station 9 (Roswell) and Station 8 (54 miles to the west) it was estimated that 75 percent of the right-of-way was rock that had to be shot. Procedure here was to rip the rock to as great a depth as possible, mark with the ditching machine, shoot, and remove with backhoes. Hand air-drills then broke up any rock missed in blasting. As many as seven wagon-drills were employed at a time, and 1500 to 2000 drill holes were made per 24-hr day during the peak of this operation.

Dirt pads in the bottom of the ditch every 20 ft were required on the more or less level stretches, and at 10-ft intervals on hills, prior to backfilling. On steep grades sack breakers (sacks filled with dirt) were used to keep the backfill from washing.

Backfill itself created a major problem. Some could be obtained from the spoil bank by a special ditch padder that removed rocks, leaving the finer soil, but in this particular area by far the greater part of the backfill was brought in by pan scrapers that had to travel approximately two miles to obtain the proper soil.

Welding units mounted permanently on tractors provide unusual mobility, even under the worst climatic conditions. They were designed by H. C. Price Co.



High melting point enamel is being applied for a distance of 25 miles on the discharge side of each compressor station; intermediate enamel on the rest of the pipe.

Pecos Crossed Twice

Two major river crossings are being made in the general Roswell area. One is 10 miles southeast of Roswell, the other 35 miles northeast, both of the Pecos. The flood plain is wide, and, although the stream is controlled now, to provide for possible eventualities aerial studies were made of past meanderings and the crossings located at switchbacks — those points at which the river tended to cross and recross in the course of cutting new channels.

Both are dredged underwater crossings laid by the main line contractors. One is 2300 ft wide, the other 700 ft, header-to-header.

The 149-mile section from Station 8 southeast of Corona approximately 25 miles, to state Highway 23, 3 miles west of New Laguna, is under the supervision of L. A. Young for the contractor, Houston. The route includes many types of terrain . . . rock, timber, rangeland. Some of the rock could be ripped and taken out by ditching machines, at other times it had to be shot and removed with backhoes. The most severe rock formations were found about 20 miles either side of and extending to Station 7, which is 12 miles southwest of Mountainaire, New Mexico. This spread had averaged from 6000 to 7000 ft a day including approximately three weeks of lost time because of snow.

Special Type Overhead Bridge

Two rivers are being crossed in this section also, the Rio Grande near Belen and Rio Puerco west of Albuquerque. Rio Puerco is an underwater crossing 1700 ft in length including approaches and is weighted with concrete river clamps. The Rio Grande, however, is an overhead bridge and constructed on

a different design than most suspension bridges. The line will be carried on trestle bents and truss piers, as illustrated in an accompanying photograph. This design was chosen because of the swiftness of the river in the spring when snow melts in the mountains, velocity of which attains 12,000 to 15,000 ft per sec. It was felt that this type bridge would better withstand such great velocity, and at the same time provide insurance against loss of footing in case of undercutting.

The overhead pipe will cover an overall distance of about half a mile, as there are irrigation canals on either side of the river that also must be spanned. To support the pipe there are 23 three-pile trestle bents and four 6-pile truss piers. In the river proper the trestle bents are driven 128 ft deep, elsewhere the piers and bents are 90 ft deep. Trestle bents extend 15 ft above ground surface and the truss piers 31 ft. Bents and piers are both constructed of 16-in. pipe. Horizontal bracings on the trestle bents are of 8⅝-in. pipe and on the truss piers of 10¾-in. pipe. Diagonal bracings on both are of 6⅝-in. pipe.

The bridge is designed for two lines, although initially only one will be installed. Design is by Wilder Kenan & Watts; construction by Harry Newton, Inc.

Problems at Continental Divide

R. H. Fulton and Company's main line section starts where the previous Houston spread finishes, 3 miles west of New Laguna, and extends to the New Mexico-Arizona state line northwest of Gallup. F. C. "Arkie" Talley is spread superintendent.

One of the unusual accomplishments on this section was the virtual knocking down of a rock mountain near Budville. To get a 6-ft right-of-way for a distance of approximately 350 ft it was necessary to shoot out the rock starting at the summit and going straight down for a distance of 60 to 70 ft.

Another right-of-way problem rarely encountered was the occurrence of lava rock both east and west of Grants, New Mexico. This formation is of a porous nature, and heavier charges of dynamite were necessary because much of the force was dissipated. After shooting, the lava rock was cleared out by backhoes.

Near the small town of Thoreau the line crosses the Continental Divide and at this altitude the frost line was around 28 in. for many weeks. In some instances rippers were run to make the job of the ditchers easier.

Quad drills are a decided asset to speed shooting in rough, rocky terrain.

The frosty weather gave rise to other procedures not customarily seen in pipeline construction. One was the use of preheaters to heat pipe ends prior to welding. The preheater in appearance resembles a nightcap used to cover the open end of a line to keep out small animals when a crew is off the job at night. It fits over the end of the pipe, in other words, and two flames heat both the inside and outside of the pipe simultaneously (see illustration). A pickup truck carrying the propane fuel tank is stationed midway of a pipe joint and both ends can be heated at the same time in a matter of 30 to 40 seconds. Desired temperature at time of welding being 113 F, the pipe was heated to 150 F to allow for heat dissipation, and the preheater operator worked only three or four joints ahead of welders.

Another intriguing piece of equipment was the defroster and this, too, was the result of the almost constant cold weather. The defroster is run ahead of the cleaning and priming machine to do what its name implies, remove frost from the pipe and assure a good bond of the primer. It encircles the pipe and is cradled by a sideboom tractor. A fuel tank on top supplies two jets that surround the pipe with flames.

Across Arizona

The line is being taken across the entire state of Arizona by two H. C. Price Company spreads. The No. 2 spread, with G. A. "Abe" Reutzel in charge, started at the New Mexico-Arizona border near Gallup, New Mexico. First field headquarters was established at Window Rock, later moved to Holbrook. It was at the latter point that the writer visited the work. Actually, activity was some 60 miles from Holbrook and about 25 miles was on the pipeline right-of-way off hard surface roads. Previous heavy snows had largely melted, but the moisture was still in the ground, freezing by night and thawing by mid-morning to plague workmen. Despite this handicap, however, the spread continued to make good footage.

Of great help under conditions of this kind was the welding equipment designed by the Price organization. Unusual mobility has been attained by mounting welding units permanently on tractors. One type equipment has four 300-amp welders attached to a D-7 Caterpillar tractor, and another has six 300-amp units mounted on a D-8. In both instances power for the welding units is supplied by the tractor engine. The equipment has been used on other jobs and is proving extremely successful on both of Price's Transwestern spreads.

Spread 2 is expecting some trouble at Schultz Pass north of Flagstaff (elevation 8200 ft), where approximately 12 miles of solid rock will have to be coped with. At the time of our visit the

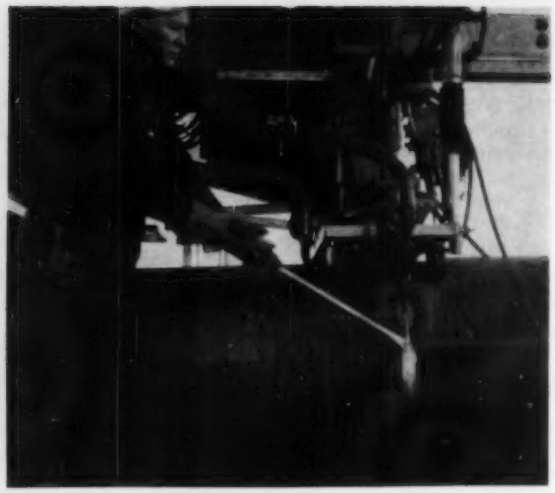
pass was under 10 ft of snow and obviously this would have to melt before construction crews could operate.

Other than this pass the most difficult right-of-way was found on the first 24 miles of the section where there was heavy shoot rock. The rock was not continuous, but something like 60 percent of it had to be shot. Good terrain existed then until the mountains were reached about 9 miles east of Flagstaff, where interspersing rocky ledges were blasted.

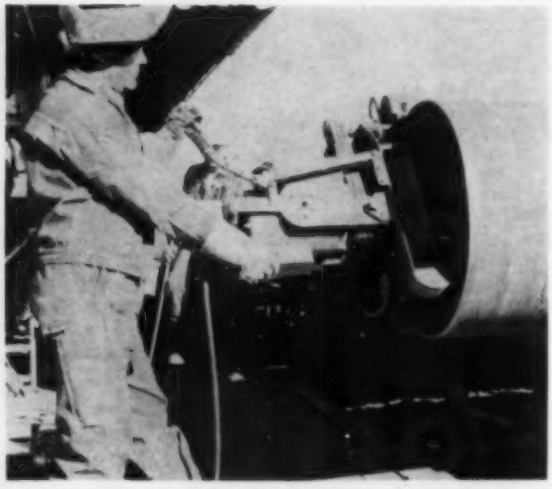
Spread No. 1, with R. L. "Bob" Ezell in charge, working east from the Colorado River at the Arizona-California border to join Spread No. 2 west of Flagstaff, had its most difficult going almost at the outset in crossing Sitgreaves Pass between Kingman and Needles. At this point the line was laid up a sheer rock cliff for a distance of one-half mile, and this half mile required 22 days of continuous shooting.

Despite this formidable obstacle, it was elected to take the route to Needles rather than going south and west to Topock. There were several reasons: (1) The Needles route saved 11 miles of pipe, 4 for Transwestern and 7 for Pacific Lighting; (2) the route through Topock traverses an especially bad wash area, which could require considerable maintenance; and (3) conditions are better at Needles for crossing the Colorado River.

Before crossing Sitgreaves Pass the spread had had relatively easy going through 8 miles of desert from its starting point at the Colorado River. After crossing this pass in the Black Mountains, the route follows a valley for 12 miles to a point near Kingman, then passes through the foothills of the Hualpai Mountains. This is broken country with deep canyons having Malapai Rock (lava) on either side. This type of terrain existed intermittently for about 30 miles. The percentage of rock was small, but shooting was tough. The right-of-way then enters grazing country underlain to some degree with rock and continues to the end of the section.



Double-jointing yard at Seligman, Arizona. Completely automatic arc-welding heads require no adjustments once controls are set. One of the basic techniques of the process is to increase the land on pipe ends from standard 1/16 in. to 3/16 in. (below).



Double Jointing

All pipe used on the two Price spreads was double-jointed in central yards by the Crose Price-O-Matic process of automatic welding. The 80-ft joints presented difficulty at times in negotiating some of the mountain turns, but saved important welding time and speeded construction. Double-jointing yards have been set up at several locations during the course of construction, being moved for convenience as work progresses. The photographs accompanying this report were taken at Seligman, Arizona, where Don Barcus was foreman for the contractor, and Tom Allen handled inspection for Gulf Interstate.

The Crose Price-O-Matic process employs completely automatic arc-welding heads that require no adjustments once the controls are set. Two beads are run on the outside of the pipe joint and one inside, the inside being made automatically the same as the outside welds by a welder riding a hydraulic powered boom.

Another basic technique is to increase the land on pipe ends from the standard 1/16 in. to 3/16 in. to simulate a backup condition. It also contributes to an admixture of the base metal into the weld metal itself, thereby conforming more closely to the analysis of the pipe and still retaining the low hydrogen characteristics of automatic welding. The thicker lands are made with special electric grinders stationed at the receiving rack.

Lineup operations are hydraulically controlled by one man from a central control point.

A complete weld is made by this method in about 4 minutes. ★ ★ ★

Prelude to a Pipeline

Survey parties for Shell's Tandjung-Balikpapan pipeline defeat bandits, insects, and jungle to prepare groundwork for an adventurous project

F. C. Livingstone, *London, England*

EARLY IN 1960 work will begin on a 20-in. pipeline, which is to be driven through 160 miles of Borneo jungle. When completed, about two years later, it will link the Shell oilfield at Tandjung and refinery at Balikpapan.

The prelude to this pipeline began in the spring of 1957 when survey parties set out from Balikpapan. The survey was designed to be carried out in three ways. The first was from the air, the second by Land Rover, and the third on foot. The second and third phases were all part of the same operation, for the roads quickly came to an end, and after that the going was so rough that any thought of vehicles was out of question.

The aerial survey took one day. It revealed that a range of mountains lay between the oilfield and the refinery, and it also revealed a solid carpet of tree tops, so thick that it was impossible to detect the land beneath.

There were two possible routes for the pipeline. One lay in a more or less straight line. It went over the highest point in the mountains (more than 3000 ft above sea level), while the other skirted the high ground, sweeping round it in a great curve to the north. Both routes had to be investigated.

A Soldier Escort

For the land survey, the party consisted of nine white men, a force of Dyaks to carry the baggage, and a sizable contingent from the Indonesian army. The soldiers were there to protect the expedition against the 200-strong gangs of bandits that infested the countryside.

The first phase of the survey was relatively simple. Land Rovers took them along 45 miles of rough and ready road, but then the highway came to an end. There was no reason for it; one moment there was road, the next, as if the road builders had suddenly tired and gone home, there was nothing. Nothing, that is to say, except a thick wall of jungle.

In all, the party made three journeys on foot. The first was to the edge of the mountains from Balikpapan. The second was from the oilfield to a point about half way along the northern route, and the third was eastward over the mountains to a river, where outboard motorboats were to take them downstream to a ship that would be waiting at the estuary.

The expedition's entrance into the jungle was prefaced by a great deal of shouting, shot firing, bolt rattling, and other military noises by the soldiery. The reason for it was simple. Within 20 minutes of starting out, the bandits would know all about the party. They would quite cheerfully kill any man for the sake of his shirt or his boots. It paid, therefore, to make them well aware that a military escort was among those present, and a fine show of martial thunder was the best way of driving the point home.

The gangs of bandits are indeed one of the main reasons why only two out of every ten Dyak children live to see the age of ten. Their method has a kind of deadly logic about it. They raid a village, burn it to the ground, rape the women, kill off all the other inhabitants who are not lucky enough to escape into the jungle, and take away all removable objects, often including the younger women. They then leave that particular village in peace for the next two years. During that period, the village is rebuilt, fresh people come to live there, the crop of paddy is revived, and it reaches a state of relative prosperity. Then the bandits return, and the cycle starts all over again.

For the Dyak, life is rough, unfriendly, and cheap. If it isn't bandits, it is an influenza epidemic, which takes an enormous toll each season, or some other kind of fever, or death by drowning from the floods (which made the pipeline survey so hazardous), or by one of the innumerable other perils that inhabit this cruel land.

When a white man sets out to explore this country, he goes into it with an arm like a disused pin-cushion. The inoculations serve him well, however, and he is a match for almost all the ailments that the jungle has to offer. But that does not make it any the more comfortable.

Route Near Equator

The countryside that the survey party had to explore is only 1½ deg from the equator. This means that, throughout the entire year, there is only 30 seconds difference between the times of sunset. It also means that there are 12 hours of blistering hot daylight and 12 long hours of night — when the rains come down.

The jungle rains in Borneo are immoderate deluges. The rivers become swollen and, on the high ground, the water builds up. When the land can hold no more, this pent-up force breaks out in what is known as a "bandji." These bandjis cascade down the sides of hills in rushing torrents 17 to 20 ft deep.

The aftermath of the bandji is the swamp. The ground at the foot of the hills becomes saturated. Walking through it, at the best of times, the traveler sinks in up to his knees. At not so good times he plows through with mud and slime licking his chin.

The explorations made by the survey party were more in the nature of a scramble than a march. Ahead of the party, Dyaks would cut a rough track through the undergrowth, but the immense trunks of fallen trees often blocked the way. There were swamps to be negotiated, rivers to be crossed. Coming down from the mountains, the ground was often coated with a film of slippery mud. The only way to negotiate it was by slithering, and hoping that there would be a root or a sapling to grab hold of before the slither got out of control.

All the time there were snakes, leeches, and other enemies of man to be watched for. And the swarms of insects that were always ready to descend on the expedition. It was these insects that made the nights so long.

Each afternoon the party would pitch camp at 3:30. A quick meal and a dip in the tepid waters of a river — crocodiles permitting — and then to bed by 5 p.m., in pajamas buttoned up tightly at neck and cuffs and with the legs tucked into socks. Then the long night began. Conversation was the only way of passing the time. To read was impossible, for it meant burning a pressure lamp, and the light would attract all the insects from the jungle.

After five weeks of this, the survey expedition at last completed its task. In that time they had laid the plans for one of the most adventurous pipelaying projects ever conceived.

Now the work for the actual construction of the pipeline is building up, but, as one of the survey expeditions put it: "It won't be so bad for them. For one thing, they'll have air-conditioned caravans and, for another, the jungle will have been cut away." ★ ★

Equivalents

Gravity API and Corresponding Specific Gravity, Weights, and Pressures at 60 F.

Gravity API	Specific gravity	Lb per gal	Lb per bbl	Lb per cu ft	Ft per lb	Lb per ft	Gravity API
10	1.0000	8.328	349.8	62.37	2.309	.4331	10
15	.9659	8.044	337.9	60.24	2.391	.4183	15
20	.9340	7.778	326.7	58.25	2.472	.4045	20
25	.9042	7.529	316.2	56.39	2.554	.3916	25
26	.8984	7.481	314.2	56.03	2.570	.3891	26
27	.8927	7.434	312.2	55.68	2.587	.3866	27
28	.8871	7.387	310.3	55.33	2.603	.3842	28
29	.8816	7.341	308.3	54.99	2.619	.3818	29
30	.8762	7.296	306.4	54.65	2.635	.3795	30
31	.8708	7.251	304.5	54.31	2.652	.3771	31
32	.8654	7.206	302.7	53.97	2.668	.3748	32
33	.8602	7.163	300.9	53.65	2.684	.3726	33
34	.8550	7.119	298.8	53.33	2.701	.3703	34
35	.8498	7.076	297.2	53.00	2.717	.3680	35
36	.8448	7.034	295.4	52.69	2.733	.3659	36
37	.8398	6.993	293.7	52.38	2.750	.3637	37
38	.8348	6.951	291.9	52.07	2.765	.3616	38
39	.8299	6.910	290.2	51.76	2.782	.3594	39
40	.8251	6.870	288.6	51.46	2.798	.3574	40
41	.8203	6.830	286.9	51.16	2.815	.3553	41
42	.8155	6.790	285.2	50.86	2.831	.3532	42
43	.8109	6.752	283.6	50.58	2.847	.3512	43
44	.8063	6.713	282.0	50.29	2.864	.3492	44
45	.8017	6.675	280.4	50.00	2.880	.3472	45
46	.7972	6.637	278.8	49.72	2.896	.3453	46
47	.7927	6.600	277.3	49.44	2.913	.3433	47
48	.7883	6.563	275.7	49.17	2.929	.3414	48
49	.7839	6.526	274.2	48.89	2.945	.3395	49
50	.7796	6.490	272.7	48.62	2.962	.3376	50
51	.7753	6.455	271.2	48.36	2.978	.3358	51
52	.7711	6.420	269.7	48.09	2.994	.3340	52
53	.7669	6.385	268.2	47.83	3.011	.3321	53
54	.7628	6.350	266.7	47.58	3.029	.3304	54
55	.7587	6.316	265.4	47.32	3.043	.3286	55
56	.7547	6.283	264.0	47.07	3.059	.3269	56
57	.7507	6.249	262.6	46.82	3.076	.3251	57
58	.7467	6.216	261.2	46.57	3.092	.3234	58
59	.7428	6.184	259.8	46.33	3.108	.3217	59
60	.7389	6.151	258.3	46.09	3.125	.3200	60
61	.7351	6.119	257.1	45.85	3.141	.3184	61
62	.7313	6.087	255.8	45.61	3.158	.3167	62
63	.7275	6.056	254.5	45.37	3.174	.3151	63
64	.7238	6.025	253.2	45.14	3.190	.3135	64
65	.7201	5.994	251.9	44.91	3.206	.3119	65
70	.7022	5.845	245.6	43.80	3.288	.3041	70
75	.6852	5.703	239.7	42.74	3.369	.2968	75
80	.6690	5.568	234.0	41.73	3.452	.2897	80
85	.6536	5.440	228.6	40.76	3.533	.2831	85
90	.6388	5.316	223.4	39.84	3.614	.2767	90
95	.6247	5.199	218.5	38.96	3.695	.2706	95
100	.6112	5.086	213.8	38.12	3.778	.2647	100

Source: Sinclair Pipe Line Company

Pipeline Projects

Line Assures More Gas For Portland Area

Construction is underway now on El Paso Natural Gas Company's 119-mile, $10,495,000 natural gas pipeline that will meet increased demands in the Portland, Oregon, area and the Willamette Valley.

Hood Construction Company and River Construction Corporation are constructing the line that starts near Camas, Washington, crosses the Columbia River, jogs toward Portland, Oregon, and then extends to Eugene via Salem and Albany. It consists of 18 miles of 20-in., 40 miles of 16-in., 25 miles of 12-in., and 36 miles of 10-in. Contractor's field headquarters are now located at Camas and Oregon City, under the supervision of Bill Burgess and Vernon Gehart.

The facilities will be used to make deliveries to Northwest Natural Gas Company.

Plans Lines, Stations, Big Gas Storage Field

A 1960 construction and replacement program that will total $10,270,000 is planned by Cities Service Gas Company on its 6800-mile natural gas pipeline system which operates in Kansas, Missouri, Oklahoma, Nebraska, and Texas.

Major items include two new compressor stations and a new 2720-acre storage field—part of a 3-year program designed to increase the capacity of the company's 26-in. pipeline from southwestern Kansas to the northeastern corner of the state.

Two new 3600-hp compressor stations totaling $2,411,000 are planned on the company's 26-in. line between the Kansas Hugoton field and the Kansas City area. One will be located near Montezuma in Gray County, Kansas, and the other near Stafford in Stafford County.

The company will spend approximately $1,778,000 this year in converting a depleted gas field 12 miles southwest of Lyons in Rice County, Kansas, into a storage facility to be known as the Alden storage field—the company's ninth in Kansas, with a capacity of 15.9 billion cu ft—with final development not scheduled for completion until 1961.

Pipeline construction planned includes about 13 miles of 16-in. from the Alden storage field northeastward to the Lyons compressor station and replacement of an existing 9-mile, 8-in. line between the Lyons station and Hutchinson with a 10-mile, 16-in. line.

Other 1960 improvements scheduled include: an additional 1800-hp compressor engine at the Alva, Oklahoma, station; connection of additional gas supply; 9 miles of 16-in. line near Wichita; increasing horsepower ratings of compressor engines at the Ulysses and Sublette (Kansas) stations; and improvement to other station facilities.

103-Mile Wyoming Crude Line

A 103-mile pipeline from Wyoming's Fiddler Creek field to the lines of Continental Pipe Line Company and Marathon Pipe Line Company at Lance Creek, with branches from an existing line in the North Donkey Creek field to Rozet field and Miller Creek field, is planned by Belle Fourche Pipeline Company, which has asked the Wyoming Public Service Commission for authority to build the $2,750,000 crude oil system.

Okays $12,798,250 Budgets

Certificates involving pipeline facilities to be constructed in 1960 at a total cost of $12,798,250 have been issued by the Federal Power Commission.

El Paso Natural Gas Company received two of the budget-type authorizations. One, to enable the company to sell and deliver natural gas to existing resale customers in Texas, New Mexico, and Arizona, includes two small-diameter pipeline laterals with a maximum estimated cost of $350,000 each; 15 meter stations at an estimated cost of from $2000 to $6000 each, or a maximum of $90,000 for the 15; and 30 main line taps, estimated to cost $275 each, for a total of $8250. The authorization limits total annual volumes to a maximum of 3,339,000,000 cu ft. The other certificate covers field facilities costing $5,000,000, with cost of single projects limited to $500,000.

Tennessee Gas Transmission Company's budget-type certificate also covers field facilities at an estimated cost of $5,000,000, with the cost of single projects limited to $500,000.

Natural Gas Pipeline Company of America will construct various facilities from time to time during 1960 at a total cost not in excess of $2,000,000, with single projects limited to $500,000.

Products Line Planned

Construction is expected to begin this month on a $5,000,000, 190-mile products pipeline from Glendive, Montana, to Minot, North Dakota, with completion planned by September.

The Farmers Union Central Exchange will build the line which will carry gasoline and diesel and burner fuel from its Laurel-Billings refinery to Minot.

An extension of the 234-mile Oil Basin Pipeline Company line which now carries fuel to member cooperatives in eastern Montana, western North Dakota, and northwestern South Dakota, it will carry up to 15,000 bbl a day 190 miles farther eastward to serve two-thirds of North Dakota.

Gathering Increase Planned

Service Pipe Line Company plans to nearly double the capacity of its crude oil gathering system in the Empire Abo field in Eddy County, New Mexico, with the addition of a new 200-hp pumping unit near Artesia, New Mexico.

The new unit will increase the company's gathering capacity to 11,000 bbl daily from a present 6000 bbl daily.

Seadrift Plans 108-Mile Texas Line

A 108-mile pipeline from Union Carbide Corporation's plant at Seadrift, Texas, to Humble Oil Company's King Ranch natural gasoline plant at Ella, Texas, is planned by Union Carbide's subsidiary, Seadrift Pipeline Corporation.

Pipe Line Technologists, Inc., will supervise engineering and construction, it has been reported.

International Notes . . .

To link Libya's Zelten field to the seaboard, Esso has ordered 100 miles of 30-in. pipe from the United Kingdom firm, South Durham Steel and Iron Company, for delivery from April through August of this year. Two other companies in Libya are planning pipelines to the seaboard: Oasis (Conorada) which has reserves estimated at one billion barrels at Bahi-Dahra, 80 miles from the coast, and Caltex which has the Beda field, about 120 miles south of the Gulf of Sirte.

Construction of the Genoa-Aigle pipeline might begin soon, and negotiations are underway for extension of the pipeline from Aigle to the Munich/Stuttgart region of southern Germany, the Societe Financiere Italo-Suisse announces.

Pemex begins construction in June of two natural gas pipelines, 12 and 8 in. from Torreon to Chihuahua. Another gas line — from Nogales, Sonora (on the Arizona border) to the port of Los Mochis, Sinaloa, on the Pacific coast — is expected to be authorized shortly.

In Canada . . .

Withdraws Intervention In Exports Hearing

Northern Ontario Natural Gas Company, Ltd., has withdrawn its intervention in the natural gas export permit application of Trans-Canada Pipe Lines, Ltd., because of a settlement by Trans-Canada of long pending terms for a supplementary contract for gas purchase.

The two companies have signed an agreement for delivery of 160,545,000,000 cu ft of gas over the next 17 years, at a total cost of $66,130,000 or an average price of just over 41 cents per Mcf for the entire term, a figure that appears to represent a concession by Trans-Canada which had previously declined to sign a long-term contract at a definite price.

A further supplementary contract was negotiated at the same time for up to 79,000,000 cu ft per day, if as and when needed, with no commitment as to quantity. The price is open, with calculation to be made on the basis of the weighted average field price of Alberta gas from reserves committed to Trans-Canada since 1957, at the time when the gas is accepted for delivery.

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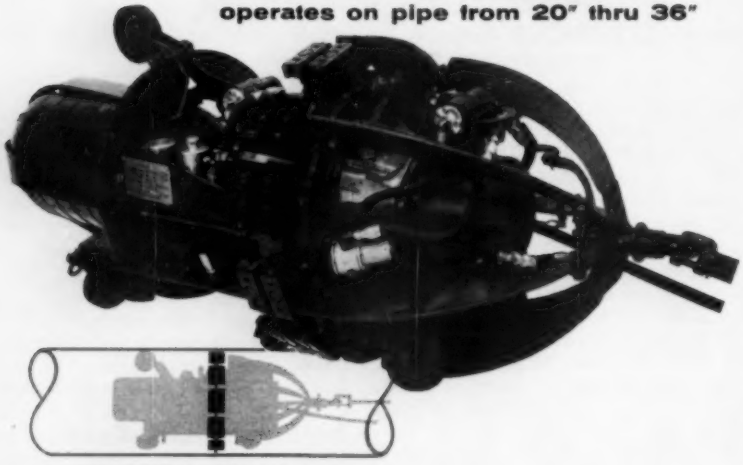

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Foothills Schedule to Depend on Energy Board

The Foothills Division of The Alberta Gas Trunk Line Company, Ltd., will not be completed, at the earliest, until the fall of 1961. This was revealed for the first time in an address by its general manager, J. C. Mahaffy, Q. C., to the recent sixth annual meeting of Pipe Line Contractors Association of Canada, dispelling a commonly held illusion that the job would be rushed to completion this year under any circumstances.

Trunk Line's construction program depends entirely upon the granting of an export permit to Alberta and Southern Gas Company, Ltd., as it will be carrying gas from all the fields which are under contract for this export project. Even if the National Energy Board grants the permit this spring, Trunk Line would build only half the Foothills line this year and the other half next year. If the Board delays until early summer, Mahaffy added, it will be a matter for decision whether the company will try to follow the original schedule or retard the whole schedule by one year, completing in the fall of 1962. This appears more likely.

Trunk Line is going ahead with a planned extension of its Plains Division in any case in 1960, but this involves the smallest capital investment of any year since it started operation.

Throughput Hits High, '60 Plans Shaping

Producers' Pipelines, Ltd., which recorded the best year in its history in 1959, plans to spend $1,000,000 in 1960 on new construction that will include 50 miles of gathering lines at an estimated cost of $750,000 and other improvements to the system at a cost of $250,000.

In 1959, it is reported, throughput reached a new all-time high of 82,221 bbl per day average delivered to terminal tankage at Cromer, Manitoba, a gain of 5432 bbl per day over 1958. The system, including its subsidiary, Westspur Pipe Line Company, which operates the main line and terminals, delivered a total of 83,721 bbl per day last year, of which 1500 bbl per day went to railway tank car siding delivery points in the fields.

Of $1,700,000 capital expenditures during 1959, $1,400,000 was spent for construction of 96 miles of new gathering lines in its southeastern Saskatchewan operating territory by Majestic Contractors Ltd., under direction of spread superintendent Jeff Minter, and $300,000 on operating improvements throughout the system.

WITH THE PIPELINE CONTRACTORS

● **Engineers Limited Pipeline Company, 11858 San Pablo Avenue, El Cerrito, California.** Has been awarded a joint-venture contract with Pacific Pipeline Construction Company for the construction of 116 miles of 34-in. pipeline for *Pacific Lighting Gas Supply Company* between Needles and Newberry, California. Lee Erlewine is superintendent at Ludlow, California.

● **Ferguson Construction Company, Box 127, Eunice, New Mexico.** Has been awarded a contract to construct 60 miles of 2 through 20-in. gas gathering system in the Maljama district between Artesia and Lovington, New Mexico, for *Skelly Oil Company*. Field headquarters are located in Lovington, New Mexico, and Wade Shipley is project superintendent.

● **Ford, Bacon and Davis Construction Corporation, Box 1762, Monroe, Louisiana.** Is working on 58 miles of 6-in. gas gathering line between Cow Island and the Mississippi River for *Goliad Corporation*. Glen Allman is superintendent, with headquarters set up in Delcambre, Louisiana.

● **Fulghum Contracting Corporation, Box 1181, Harrisburg, Pennsylvania.** Has been awarded a contract by *Niagara Mohawk Power Corporation* to lay 122 miles of 12-in. natural gas pipeline between Watertown and Massena, New York, including six crossings involving the Black, Grass, Racquett, and Oswegatchie rivers.

● **R. H. Fulton & Company, P. O. Box 1526, Lubbock, Texas.** Has been awarded a joint contract with Houston Contracting Company and Western Pipe Line, Inc., to lay approximately 300 miles of 16, 12, and 10-in. trunk lateral lines in the Texas-Oklahoma Panhandle and West Texas-New Mexico area for *Transwestern Pipeline Company*. Has received a contract from *El Paso Natural Gas Company* for construction of 126 miles of 30-in. pipeline in various loops across New Mexico, paralleling the company's existing line, and has named H. A. Tinkler superintendent and has located the field office at Tatum, New Mexico.

● **Hood Construction Company, 8201 South Sorensen Avenue, Whittier, California.** Has in progress a joint venture with J. P. Neill Company and River Construction Corporation involving the construction of 32 miles of 36-in. pipeline between Cucamonga and Placentia, California, for *Southern California Gas Company* and *Southern Counties Gas Company*. Cecil Jernigan and Merle Tatum are supervising at Chino, California. Another joint venture with River Construction Company has been awarded by *El Paso Natural Gas Company*, involving 120 miles of 10, 12, 16, and 20-in. pipeline from Portland to Eugene, Oregon. Field offices are at Camas, Washington, and Oregon City, Oregon, under the supervision of Bill Burgess and Vernon Gehart.

● **Houston Contracting Company, 2807 Buffalo Speedway, Houston 6, Texas.** Has been awarded a contract by *Transwestern Pipeline Company* to lay the following: 149 miles of 30-in. from the vicinity of Corona, New Mexico, west to the vicinity of McCartys, with L. A. Young as superintendent; 55 miles of 30-in. and 89 miles of 24-in. from Corona, east to Roswell and southeast to Carlsbad, with M. L. Thompson as superintendent; 61 miles of 20-in. and 76 miles of 24-in. from the vicinity of Fort Stockton, Texas, northwest to the vicinity of Carlsbad, New Mexico, with A. J. Slovack as superintendent; 166 miles of 24-in. from Roswell, northeast to the vicinity of Dawn, Texas; and a joint contract with R. H. Fulton & Company and Western Pipe Line, Inc., for approximately 300 miles of 16, 12, and 10-in. trunk lateral lines in the Texas-Oklahoma Panhandle and West Texas-New Mexico area.

● **Mannix Company, Ltd., 737 - 8th Avenue, S. W., Calgary, Alberta, Canada.** Has been awarded a contract by *Alberta Gas Trunk Line Company, Ltd.*, to construct a 24-in. natural gas pipeline crossing of the Red Deer River. Red Deer, Alberta, is headquarters; and O. L. Lee, superintendent. Is constructing a 70-mile, 3 through 6-in. Pembina oil field gathering system for *Pembina Pipeline Company, Ltd.*, with S. Steffen as superintendent at Drayton Valley, Alberta.

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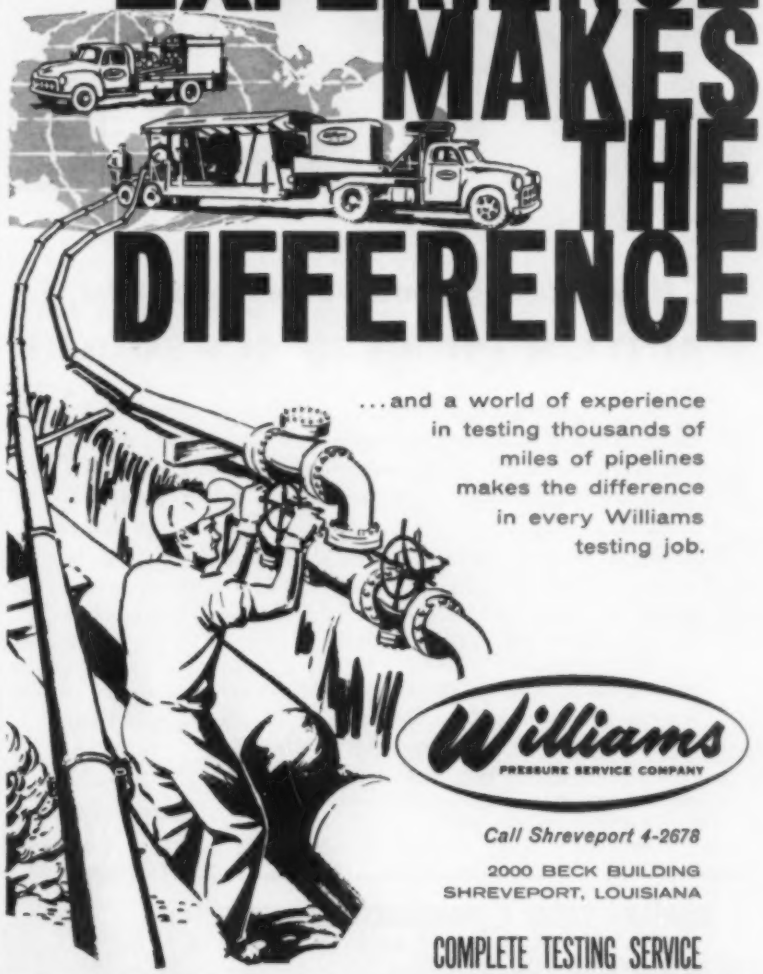

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● **Missouri Valley Dredging Company, P. O. Box 1592, Burlington Station, Omaha 8, Nebraska.** Has been awarded a contract by *Pacific Lighting Gas Supply Company* to construct the dual 24-in. pipeline crossing of the Colorado River near Needles, California. Topock, Arizona, will be headquarters. Harold H. Hubbard and Charles E. Hobbs are superintendents.

● **J. P. Neill and Company, 522 Meadows Building, Dallas, Texas.** Has been awarded a joint contract with Hood Construction Company and River Construction Corporation to construct for *Southern California Gas Company* and *Southern Counties Gas Company* 32 miles of 36-in. gas pipeline between Cucamonga and Placentia, California.

● **Pacific Pipeline Construction Company, 1632 S. Greenwood Avenue, Montebello, California.** Has received a joint contract with Engineers Limited Pipeline Company to construct 116 miles of 34-in. pipeline for *Pacific Lighting Gas Supply Company* between Needles and Newberry, California. Field office will be located at Ludlow, California.

● **Panama, Inc., 2201 Commerce Building, Houston 2, Texas.** Is constructing 117 miles of 30-in. gas pipeline in Mississippi and Tennessee for *Trunkline Gas Company*. Spread No. 1 is now at Somerville, Tennessee, under the supervision of A. J. "Buck" McIntyre, Jr.; Spread No. 2 at Union City, Tennessee, under the supervision of Carl J. Hendrickson; and Spread No. 3 at Marks, Mississippi, under the supervision of M. C. "Tex" Johnson.

● **H. C. Price Company, Price Tower, Bartlesville, Oklahoma.** Has two spreads working on 336 miles of 30-in. pipeline across Arizona for *Transwestern Pipeline Company*. Spread One, supervised by G. A. "Abe" Reutzel, began construction at Window Rock and is now headquartered at Holbrook. Spread Two under the supervision of R. L. "Bob" Ezell began at the California-Arizona border, working east, and is now headquartered at Seligman.

● **River Construction Corporation, Box 9127, Fort Worth 7, Texas.** Has been awarded a joint contract with J. P. Neill and Company and Hood Construction Company to construct for *Southern California Gas Company* and *Southern Counties Gas Company* 32 miles of 36-in. gas pipeline between Cucamonga and Placentia, California. Has been awarded a joint contract with Hood Construction Company to construct for *El Paso Natural Gas Company* 120 miles of 10, 12, 16, and 20-in. gas pipeline from Portland to Eugene, Oregon.

● **Sheehan Pipe Line Construction Company, 514 National Bank of Tulsa Building, Tulsa, Oklahoma.** Has received a contract from *Transwestern Pipeline Company* to construct 300 miles of 4, 6, and 8-in. gathering lines in West Texas, Oklahoma, and New Mexico. Field office for first spread is now in Perryton, Texas, under the supervision of J. W. Brown; and field office for the second spread, in Monahans, Texas, under the supervision of Boyd Douglas.

● **Young and Anderson Company, Box 68, Brea, California.** Has been awarded a contract by *Southern California Gas Company* and *Southern Counties Gas Company* to build approximately 85 miles of 36-in. pipeline from Newberry to Cucamonga, California. Jack Cook and R. R. "Ronnie" Cook have been named project superintendents.

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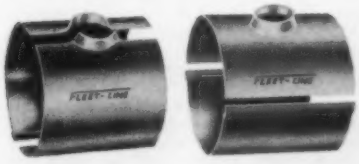

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PIPELINE PERSONALS

▸ **Richard J. Plank** has been elected a director of Consolidated Natural Gas Company and named president of New York State Natural Gas Corporation, a Consolidated System subsidiary, succeeding **Fenton H. Finn** who has retired from corporate management to become a consultant on matters of gas production and storage. Finn is being retained to work on production and storage problems of all the Consolidated System companies.

R. J. Plank

▸ **L. H. True,** president of Magnolia Pipe Line Company, has announced key personnel appointments that are the result of the consolidation of three Mobil Oil Company pipeline divisions with the Dallas-based Mobil affiliate. **J. E. McGeath,** formerly assistant manager, has been named manager of operations; **S. L. Westlake,** formerly manager of mechanical and civil engineering, becomes manager of pipeline development; **C. M. Brecheisen,** formerly manager of the Eastern Pipe Lines Division at Plainfield, New Jersey, has been named manager of engineering; **M. R. Anderson,** formerly manager of personnel and policy, becomes manager of employee relations; **T. E. Christopher,** formerly assistant manager of personnel and policy, now employee relations advisor; **P. E. Edwards,** formerly safety supervisor of the Eastern Pipe Lines Division, now supervisor of safety and training.

▸ **"Art" Stewart** and **T. L. Dean** have been named supervisors in Texas Gas Transmission Corporation's general office dispatching, **George Thompson** has been appointed an agent in the land and lease department, and **James E. Hewett** has been made supervisor of dispatching at Memphis, Tennessee, and will continue as division superintendent of measurement.

▸ **K. E. Kalen** has been appointed assistant to **F. J. McElhatton,** vice president in charge of gathering and transmission for Panhandle Eastern Pipe Line Company. Other promotions in the company's compressor section include: **G. J. Gillian,** superintendent of compressor stations; **C. J. Witt,** assistant superintendent of compressor stations.

▸ **Theodore H. Gunst,** Sun Pipe Line Company employee for 14 years, has been appointed administrative assistant to **W. C. Kinsolving,** president. Prior to joining Sun Pipe Line as personal secretary to the president, Gunst served Sun Oil Company and subsidiary companies for 22 years, beginning as a secretary and geological draftsman.

▸ **Albert E. Bradbury,** superintendent of the compressor department of Ohio Fuel Gas Company, has retired and is succeeded by **Burdette M. King** who has been assistant superintendent since 1952. **Clarke Kiner,** general engineer, succeeds King.

▸ **R. L. Taylor** has been named a director and vice president and **E. J. Wacker, Jr.,** a director of Magnolia Pipe Line Company, **L. E. Frensley** was elected treasurer and **James R. Ball,** assistant secretary.

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Speediest application — slotted lug permits the single plated bolt to slide instantly into place.

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DEMA Elects E. L. Miller

Eugene L. Miller, president of The Cooper-Bessemer Corporation, has been elected president of the Diesel Engine Manufacturers Association succeeding John N. MacKendrick, board chairman of Clark Brothers Company.

Association vice presidents include George Steven, Worthington Corporation; and William E. Butts, General Metals Corporation. Robert L. Stanley continues as executive secretary of the group.

Sales personnel from six regional offices of Daniel Orifice Fitting Company who recently attended a two-day session on sales policies and goals at the Houston, Texas, home office and plant were: top row, left-to-right, Herbert H. Hodgeman, J. B. Corzette, Alex H. Curry, Mert Freudenthal, Paul Pirkle, Malcolm Bell, Joe Holdenried, F. N. Davis, Alphonsine Ring, R. H. Clemons, Jr.; middle row, Larry Irving, Ken Kendall, Vic Morgan, Don Darais, Bill Henry, Eddie Kral, J. H. Mitchell, Carroll O. Cox; and front row, L. W. Wilbern, Glenn W. Daniel, Bill Watson, John Russell, Rex W. Landry, J. R. Wilson, and J. Virgil Moore.

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In Pipeline Felt Sales

Nicolet Industries, Inc., has placed as southwest district sales manager in direct charge of its pipeline felt sales John H. Caldwell, 11701 Wink Drive, Houston 24, Texas. The territory, under Caldwell's supervision, includes Texas, New Mexico, Oklahoma, Kansas, Arkansas, Louisiana, and Mississippi.

Motorola Promotes Falls

Edward L. Falls, Jr., has been promoted to executive assistant to the general manager of Motorola's communications division. Succeeding Falls as a vice president of the wholly-owned subsidiary, Motorola Communications and Electronics, Inc., in which he managed sales and service in the southern states, is Robert N. Swift, formerly vice president and manager of the midwest sales area. Robert F. Davis, formerly two-way radio sales manager for the midwest area, succeeds Swift.

Creates New Post

Pittsburgh Coke and Chemical Company has elected to the new post of vice president-administration Putman B. McDowell, formerly assistant to the president. McDowell will be responsible for administration of general corporate policy and coordination of line and staff activities.

Marketing Director Named

H. D. (Buzz) Leisenring has been named director of marketing for the Smith-Erie Division of the A. O. Smith Corporation. Other changes to meet total marketing requirements include: William B. Johnson as sales promotion manager and assistant to the director of marketing; John S. Thompson as sales manager of special products; and J. W. (Winnie) Harris as sales manager of meter products.

C-B Names En-Tronic Heads

Frank L. Friedli has been named manager and Reed D. Hamilton, assistant manager, of The Cooper-Bessemer Corporation's En-Tronic Controls Division as a further step by the company to give its activities in the engine and compressor controls field full divisional status.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Pipeline Equipment . . .

Rectifiers Monitored From Aircraft

Aerial Survey Indicator is a new device which enables aircraft to monitor the condition of cathodic protection stations in remote or isolated areas. It monitors

the current to the pipeline being protected. It consists of two separate components: a control box, mounted in the rectifier station housing, which performs the monitoring or sensing function; and an indicator, mounted on the pole above the station, which gives the visual indication by rotating under normal condition and becoming motionless when there is power failure, insufficient current level, excessive current, or failure of components. Applicable primarily to monitoring cathodic protection stations, it may be used to monitor any equipment in inaccessible or remote locations. *Pipetron Co.*

Circle number (81) on reply card.

Plain End Pipe Package

A new piping method for connecting plain end pipe has been developed. No pipe end preparation is required. The Plainlock Method consists of Plainlock couplings and Plainlock fittings, available in 1, 2, 2½, 3, 4, and 6-in. sizes, for use with plain or beveled end pipe. The couplings are designed with two bolts for fast, easy installation and are fitted with hardened stainless steel grips that engage the pipe ends and securely lock them together. An ordinary wrench with normal torque is sufficient to seat the grips in the pipe or fitting ends. "Triple-Seal" gaskets are said to assure leak-tightness and long life. The fittings are engineered with long radii "Full-Flow" sweeps for good hydraulics and minimum friction loss. Ample wall thickness protects against corrosion and abrasion. *Victaulic Co. of America.*

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MODEL	TRENCH WIDTHS	MAX. DEPTH	DIGGING SPEEDS
130	12 to 24 in.	5¾ ft.	12 in. to 18 ft. per min.
150	16 to 26 in.	5¾ ft.	12 in. to 25 ft. per min.
170	20 to 32 in.	5¾ ft.	12 in. to 25 ft. per min.
420	36 to 52 in.	7½ ft.	15 in. to 25 ft. per min.
520	40 to 52 in.	8½ ft.	12 in. to 28 ft. per min.

Also: 5 ladder-types for digging 6 INCHES to 6 FEET wide . . . up to 19 FEET deep

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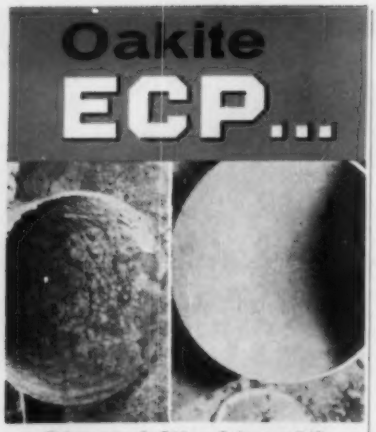

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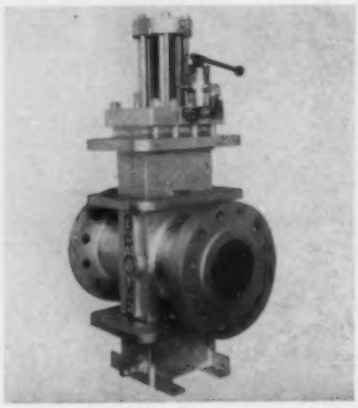
New Valve-Operator With Fewer Parts

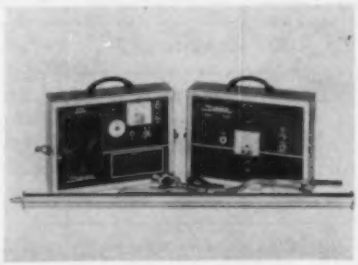


Designed for general pipeline service and said to have unique advantages where operating speed or remote control is necessary, such as offshore applications or river crossings, is a new piston cylinder operator-valve combination with reduced size brought about by the valve stem acting as a piston rod, bringing the cylinder very close to the valve bonnet. In some sizes, the valve bonnet actually becomes the lower cylinder head of the operator. Below the bonnet is featured a parallel faced gate that slides between floating seats. The seal is accomplished by polished metal seal rings with nitrile rubber "O" rings held against the gate. No lubrication is required. A newly designed 4-way valve controls the cylinder. A variable orifice on the exhaust of the 4-way valve controls the operating speed. *Grove Valve and Regulator Co.*

Circle number (83) on reply card.

Transistor Pipe Detector

A new transistor pipe detector has been introduced, with circuitry specifically designed to utilize transistors to their fullest advantages. Inadequacies such as heat limitations are said to be eliminated by



the 808 Detectron's use of special compensating circuitry, thus making the instrument suitable for use in hot southern climates. Two transistors instead of one are used in the transmitter so that maximum power is available with no sacrifice of stability. It traces pipes and cables by the conductive method, particularly advantageous in areas with highly mineralized soil or many abandoned pipelines. Cut-off is said to be unusually sharp assuring separate detection of pipelines lying close together. Maximum depth range on large lines is 20 to 25 ft depending upon soil conditions. *Computer Measurements Company.*

Circle number (84) on reply card.

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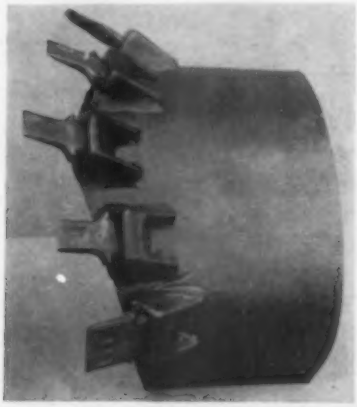
Remote Control Measurement

Heart of equipment for remote control measurement of onstream petroleum products is the Granco Duo Rotor, a 12-in. diam, turbine-type meter with a rated capacity of 7100 bhp at pressures up to 300 psi. It is scheduled for use on refined products through No. 2 fuel oils. Opposite pitch dual rotors, geared as a unit,

develop twin-drive power to operate the meter counters at all flow rates, from high to low. The meter operating counter records throughput in 100th-bbl. Recordings are retained on totalizer dials so that accumulative data is available for split runs or batch stream movements. Connected to the operating counter is a Selsyn drive that transmits to a remote desk counter which also records in 100th-bbl, has accumulator dials, and a flow indicator that informs the control operator of the rate of stream-flow in 100-bbl-per-hr increments. A calibration counter that operates off the same drive as the operating counter proves the meter to be within 100th-bbl accuracy. *Granberg Corp.*

Circle number (85) on reply card.

For Hard-to-Get Rock



A new shovel-nose bucket has been announced for hard-to-get rock, caliche, or hard soil. Time-tested under the toughest conditions, it is said to increase footage with decreased maintenance and to offer ease of penetration, more dirt capacity. *Jetco, Inc.*

Circle number (86) on reply card.

Indicates Load Weight

Developed for the Metal and Thermit Corporation and in use on the clamshell bucket of their crane to activate a series of lights indicating pickup load weight is a new force control switch that incorporates attachment eye and yoke integrally machined as part of the deflection beam. Under load, the "U"-shaped beam moves outwardly. Switches contained in dust and moisture-proof housing at center are actuated at various pre-set load points by means of recessed adjustment screws in the lower half of the beam. They provide low-cost automation of any applications involving force or weight such as overload prevention on hoists or cranes. *W. C. Dillon & Co., Inc.*

Circle number (87) on reply card.

Off-The-Shelf Unit

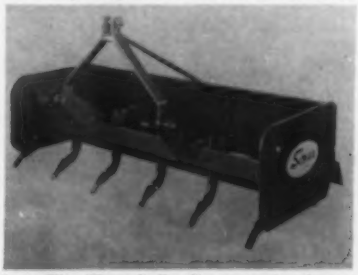
A small, lightweight, general purpose unit has been developed for long distance transmission of control and monitoring data that is capable of solving approximately 80 percent of control problems without any modification whatever. The

basic design is such that, in those cases where modification is required, it can be simply achieved with standard "add-on" modules. Transistorized, the basic unit is capable of measuring and transmitting eight variables (temperature, pressure, viscosity, etc.) and also transmitting 16 on-off functions (alarms, valve positions, pump conditions, etc.). It also can receive on-off commands, set points, and similar data from a central controlling facility and cause pumps and valves to operate and various local controllers to change their control set points. *International Controls Corp.*

Circle number (88) on reply card.

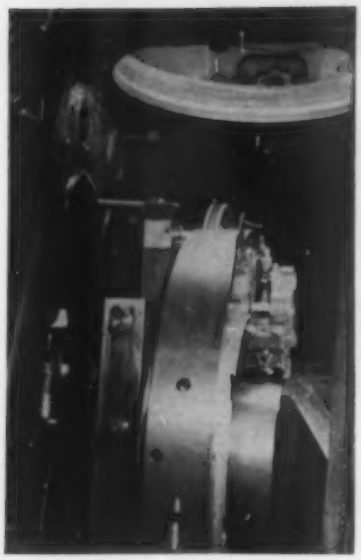
Soil Scraper

Announced is a new economy model soil scraper, applicable to backfilling and leveling, that gives the pipeliner the option of getting what seems to fit his needs



best. The "Seco Jr." soil scraper has heavy duty qualities, but scarifier teeth assembly is optional. When scarifier teeth are specified, they will be manually inserted, instead of using the hand lever feature for lifting as found on standard models. *Servis Equipment Co.*

Circle number (89) on reply card.



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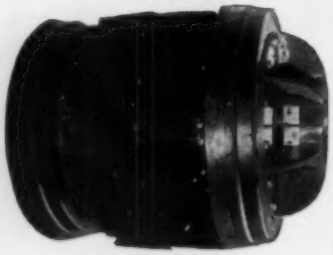

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Recommended Points In Holiday Inspection

A specification guide for electrical holiday detector inspection is being issued. It gives recommended points to be included in a specification for the electrical inspection of thin film coating with the "non-destructive" type holiday detector; for the electrical inspection of hot applied bituminous or prefabricated protective film coatings; and for the inspection of a coated pipeline or other metal structures after they have been buried in the ground. *Tinker and Rasor.*

Circle number (90) on reply card.

Visual Lube Control

For extending the time period between lubricator filling is a simply installed flow oil control that can be tied into the main engine gear pump to receive its oil from the crankcase after the oil has been filtered. In a catalog page that describes it, it is pointed out that there is no need for any additional tapped hole to overflow excess oil from the lubricator reservoir. The number of oil drops appearing in the input sight glass are proportionate to the total number of drops being taken out by all the lubricator feeds. *McCord Corp.*

Circle number (91) on reply card.

Non-Chattering Valve

A new bulletin describes Lonergan's non-chattering Hydro-Valve line for liquid service, giving complete details and specifications on sizes, capacities, materials, and other pertinent data. *J. E. Lonergan Co.*

Circle number (92) on reply card.

Ripping for Profit

How ripping can increase profits is described in a new 8-page brochure just released by Caterpillar Tractor Company. Construction details and operation of rear-mounted, hydraulically-operated rippers for the Cat D9, D8, D6, and D4 tractors and No. 977 and 955 Traxcavators are included. *Caterpillar Tractor Co.*

Circle number (93) on reply card.

Pipe Fluoroscopy

Limitations and advantages of conventional fluoroscopy, basic principles, preliminary investigations, pilot installation, production unit, and fluoroscopic standards for mill control of weld quality are covered in a new 12-page booklet entitled "A Progress Report on Continuous Fluoroscopic Inspection of Submerged-Arc Welded Line Pipe." Prepared by A. B. Wilder and E. B. Henry, Jr., National Tube Division, U. S. Steel Corporation, for a recent panel session on non-destructive testing, it is illustrated with photos, radiographs, and drawings, and contains a schematic plant layout for the fluoroscopic unit. *Philips Electronic Instruments.*

Circle number (94) on reply card.

Valve Design, Operation

The full opening, non-lubricated, new Keroseal valve—with vapor-tight seal, optional flow, and double block and bleed—is graphically described in design and operation in a new folder. Applications: pipelines, terminals, manifolds, marine terminals, etc. *Kerotest Mfg. Co.*

Circle number (95) on reply card.

Mobile Welding Unit

A mobile welding unit is the subject of a new 4-page, 2-color folder. It is the International TD-15-500-1 Paywelder—a factory-engineered-and-manufactured rig carrying two 325-amp dual welders with four leads, constituting a compact 120-hp package capable of efficiently pushing through swamps and over mountains to get to the job site. *International Harvester Co.*

Circle number (96) on reply card.

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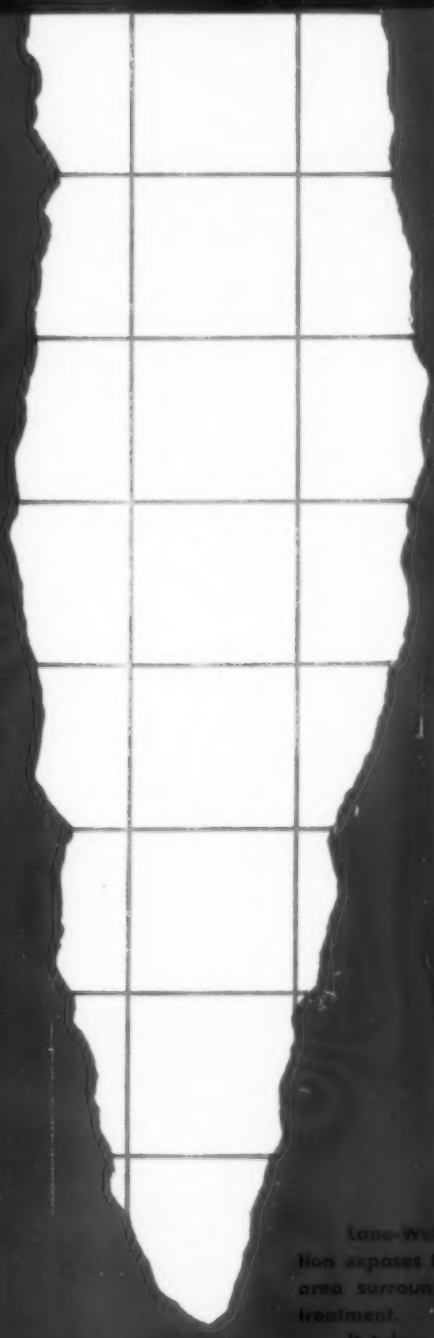

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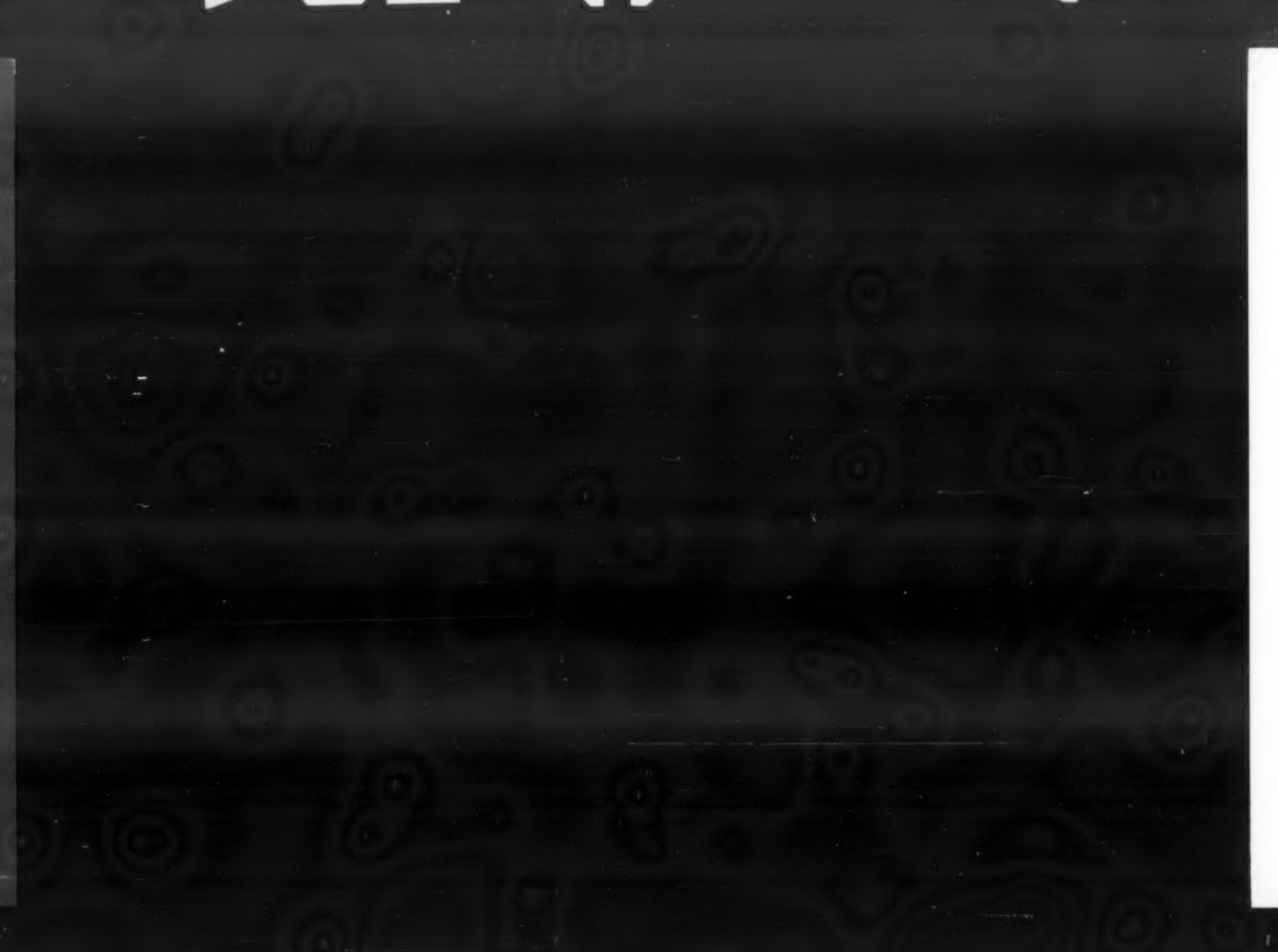
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